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A STUDY OF A WOOD MOUSE POPULATION IN WYTHAM WOODS, BERKSHIRE

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The wood mouse, *Apodemus sylvaticus*, is common throughout the British Isles and Europe and eastward into Asia (Matthews, 1952). Ecologically it is one of the most adaptable and important of the European small mammals but, like most common species, it has attracted very little attention from ecologists. The wood mouse has been studied far less than its American counterpart, *Peromyscus maniculatus*, although detailed comparisons between the two would be extremely valuable as a guide to the nature of the population dynamics and community relationships of small mammals.

This study was done in a five-acre copse known as "The Pasticks," 4½ miles northwest of Oxford in Wytham Woods, Berkshire. The Pasticks is a mixed-wood copse; it is surrounded by arable fields and was chosen for its relative isolation from adjacent woodlands. The dominant vegetation of the copse is an oak-ash-sycamore association (*Quercus robur—Fraxinus excelsior—Acer pseudo-platanus*) modified by plantings of elm (*Ulmus campestris*), birch (*Betula alba*), beech (*Fagus sylvatica*) and sweet chestnut (*Castanea sativa*). A long history of natural development without management has allowed the formation of a relatively primitive woodland. The dense canopy and deep shade of this woods is reflected in the simplicity of the shrub and field layers of vegetation. Hazel (*Corylus avellana*) and elder (*Sambucus nigra*) occur scattered through the woods and the field layer is composed almost entirely of Dog's Mercury (*Mercurialis perennis*) and nettle (*Urtica dioica*). The edge of the copse is bordered by an unkept hawthorne hedge (*Crataegus oxyacanthoides*) which has grown to heights of 10 and 12 feet in places.

Most of the seed foods produced in the Pasticks are palatable to wood mice (Miller, 1954) and 1950 seemed to be an exceptionally good year for seed production. The seeds of oak, beech and chestnut seemed to be selected by the mice and disappeared rather early from the floor of the woods, but sycamore seeds were abundant on the ground for several months and hawthorne fruits were still present at the start of the 1951 growing season. It can safely be assumed that food supplies for the mice were abundant, even during the winter of 1950–51.

METHODS

A grid of 41 squares, each 25 yards on a side, was laid out as shown in Fig. 1. Each of the 41 squares consisted in turn of 25 smaller squares (1 × 1 yd.) in which traps were set according to a schedule of random trap placements predetermined from random number tables. The entire area was trapped once each month with two Longworth live traps (Chitty and Kempson, 1949) placed at random within each of the 41 squares. The traps were prebaited with oats for two days, set at about 5 PM on the second day, and visited at about 9 AM on the third day. The animals were marked with monel rings (Chitty, 1937) and released, after appropriate data on sex, weight and reproductive condition were recorded.

Although the technique of prebaiting is designed to overcome "trap-shyness," many small mammals, and especially *Apodemus*, may also become "trap-addicted." If the mice become accustomed to finding food in traps which are left in place for several days, they are not only stopped before they can reveal the extent of their home range, as pointed out by Chitty (1937), but certain individuals may also exclude others from capture (Chitty and Kempson, 1949; Tanaka, 1951). Although Brown (1954) found that a large percentage of the mice he trapped did not return to traps that were left in place for several days, preliminary experiments during this study showed that some individuals

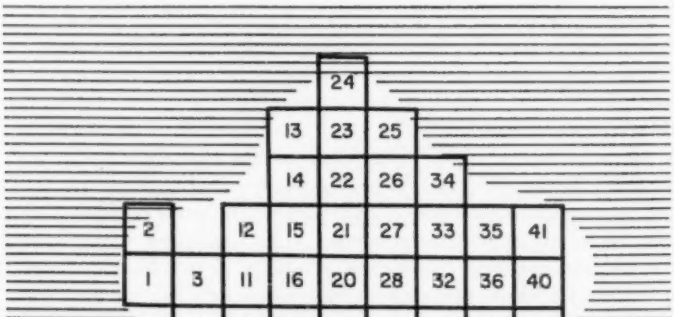

FIG. 1.—Pasticks trapping grid. Arable fields surrounding the copse are indicated by cross-hatching.

TABLE 1.—*Numbers of Apodemus sylvaticus, Clethrionomys glareolus and Sorex araneus trapped from January, 1950 to March, 1951*

MONTH	*Apodemus*	*Clethrionomys*	*Sorex*	TOTAL
1950				
Jan.	28	6	1	35
Feb.		no sample		
Mar.	20	6	0	26
Apr.	18	8	0	26
May	19	10	6	35
June	22	12	10	44
July	2	14	6	22
Aug.	22	18	3	43
Sept.	48	4	1	53
Oct.	48	4	6	58
Nov.	48	3	0	51
Dec.	8	2	0	10
1951				
Jan.	40	4	4	48
Feb.		no sample		
Mar.	30	3	0	33
Total	352	94	37	483

do indeed return repeatedly to the same trap site. To overcome sampling errors of this sort, two traps were placed at each position, the trap sites were selected randomly, trapping periods were short and the trapping campaigns were widely spaced.

RESULTS

1. Relative numbers of mice, voles and shrews.

The numbers of mice, voles and shrews trapped each month are shown in Table 1. Voles (*Clethrionomys glareolus*) and shrews (*Sorex araneus*) seemed to be especially abundant during the months of May, June, July and August, partly because of a real increase in their numbers but perhaps also because of the nature of their activity. Wood mice (*Apodemus sylvaticus*) are more nocturnal than either voles or shrews (Crowcroft, 1954; Miller, 1955) and their movements are less affected by the presence or absence of protective cover. During the winter, when there is no ground layer of vegetation and protective cover is sparse, voles, and probably shrews as well, are seldom trapped any distance from logs, bramble patches, or stands of bracken (Evans, 1942; Miller, 1955); but during the spring and summer, when the ground is covered with dense stands of Dog's Mercury and nettle, they are able to range over greater areas under the protective cover of vegetation. Moreover, as mice do not seem to take advantage of cover as voles do, their activity rhythms are more sensitive to changes in day length and their activity is more restricted by short summer nights (Miller, 1955). Consequently, traps set at random in an area

such as the Pasticks will have a higher probability of capturing voles and shrews in summer than in winter, and the results shown in Table 1 probably reflect changes in activity pattern as well as seasonal trends of abundance.

TABLE 2.—*Seasonal changes in abundance and activity of Apodemus sylvaticus from January, 1950 to March, 1951*

MONTH	TOTAL CAPTURES ♂♂	TOTAL CAPTURES ♀♀	NUMBER/100 TRAP NIGHTS	KNOWN POPULATION	NUMBER /ACRE	PER CENT RECAPTURES	PER CENT FEMALES REPRODUCTIVE
1950							
Jan.	14	14	37.3	28	5.3	0.0	0.0
Feb.	no sample						
Mar.	10	10	26.3	22	4.2	65.0	44.4
Apr.	9	9	24.3	21	4.0	88.9	75.0
May	8	11	28.8	19	3.6	78.9	90.0
June	8	13	31.4	22	4.2	28.6	84.6
July	1	1	3.2	7	1.3	0.0	100.0
Aug.	8	14	36.1	24	4.5	10.4	85.7
Sept.	31	17	62.3	51	9.6	12.2	70.6
Oct.	30	18	66.7	54	10.2	29.2	11.8
Nov.	21	27	60.8	58	10.9	41.7	0.0
Dec.	5	3	10.0	39	7.4	75.0	0.0
1951							
Jan.	23	17	54.0	44	8.3	72.5	5.3
Feb.	no sample						
Mar.	19	11	38.0	30	5.7	83.3	61.5

2. Seasonal trends in the *Apodemus* population.

a. *Sex ratio.*—Elton *et al.* (1931) observed remarkably consistent variations in the sex ratio of *Apodemus* during two consecutive seasons; the proportion of males rose to its highest in late summer and early autumn and dropped to equality with the females during winter and spring. Evans (1942), on the other hand, found only slight but irregular variations in sex ratio and his data show no consistent trends. The number of males and females captured each month during this study are shown in column 2 of Table 2. When tested for chi-square the relative numbers of males and females were found to diverge from unity only in the September sample, although the values for October are nearly significant and should be considered part of the same trend (Snedecor, 1956). The preponderance of males during these two months is similar to the situation reported by Elton *et al.* (1931), although it occurred slightly later in the season than was the case in their study. Elton *et al.* (1931) considered that this phenomenon might be associated with breeding activity and a tendency for the males to wander more and therefore be more liable to capture at this time of the year. Males were more active and moved greater distances than females during September and October and may have been

more liable to capture, but they were also more active than females during March and April when the sex ratios were equal.

b. *Breeding.*—Column 7 of Table 2 shows the percentage of the females in each month's sample that showed external evidence of reproductive activity. The criteria used were a swollen vulva, perforate vagina, lactation or visible pregnancy. These criteria have certain rather obvious shortcomings, but are sufficient to establish a rough index of breeding activity and the extent of the breeding season.

The breeding season in wood mouse populations usually begins in March, reaches a peak in June and July, and ends by October or November, although cessation of breeding through the winter is not an invariable rule. During a three-year study in Bagley Wood near Oxford, Baker (1930) and Elton *et al.* (1931) found that breeding ceased for six months during the first winter, during two months of the second winter and only during one month of the third winter. There was no apparent correlation between winter breeding and environmental conditions, but their data do suggest that it might have accompanied a yearly increase in population density.

The data shown in Table 2 are similar to those reported by Baker (1930) for the second year of his study. None of the animals trapped in January, 1950, was in breeding condition but by March the testes of all of the males were scrotal and 44.4 per cent of the females were reproductive. By April, 75.0 per cent of the females had perforate vaginas or swollen vulvas, although none was lactating or visibly pregnant, and by May, when the first juvenile was trapped, 90.0 per cent of the females were breeding. By this time many were lactating or pregnant. Breeding continued into October and had apparently ended by November, but by January 5.3 per cent of the females showed signs of reproductive activity and the proportion had increased to 61.5 per cent by March, 1951. Baker and Ranson (1932 *a*, *b*) have shown that light, temperature and nutrition control breeding in *Microtus agrestis* and we may logically assume that this combination of factors is also important in the breeding cycle of *Apodemus*. Of these factors, nutrition seems most likely to have been an important variable responsible, in part at least, for the extended breeding season of 1950–51. A second factor should also be considered, however; small mammal numbers were relatively high in Wytham Woods in 1950 and 1951 and it is quite possible that the same correlation between population density and breeding that was noted by Elton *et al.* (1931) existed during this study.

c. *Age structure and mortality.*—*Apodemus* seldom live more than a year in the field and the overwintering population that is established by late fall consists almost entirely of young born that year (Elton *et al.*, 1931; Evans, 1942). This fact is evident in the recapture data in column 6 of Table 2. After the initial marking in January, 1950, the percentage of recaptures increased to 88.9 per cent by April but declined from May onwards as the population was diluted by young of the breeding season. The unusually low number of captures

in July was apparently due to a mass migration into the grain fields adjacent to the north edge of the copse. During this period the mice moved as far as 50 yards away from the woods and into the fields, harvesting the ripe grain. Five of the mice captured in August had been marked during the preceding months, however, showing that the July exodus was to some extent temporary, even though the period between June and August was apparently one of high mortality. Recaptures became more frequent in October and in subsequent months as breeding declined and the overwintering population became established. Of the mice marked between January and July, 1950, only five were recovered as late as August, two were still present in September, and none was taken in October or subsequent months and the October population consisted, therefore, of animals born in 1950, probably during the latter part of the breeding season.

Changes in weight distribution from August, 1950 to March, 1951 are shown in Table 3 and Fig. 2. Baker (1930) concluded that mice weighing 15 grams or more may be classed as adults, although it does not necessarily follow that those weighing less than 15 grams are sexually immature. Wood mice may breed when only a few months old and it was common in the present

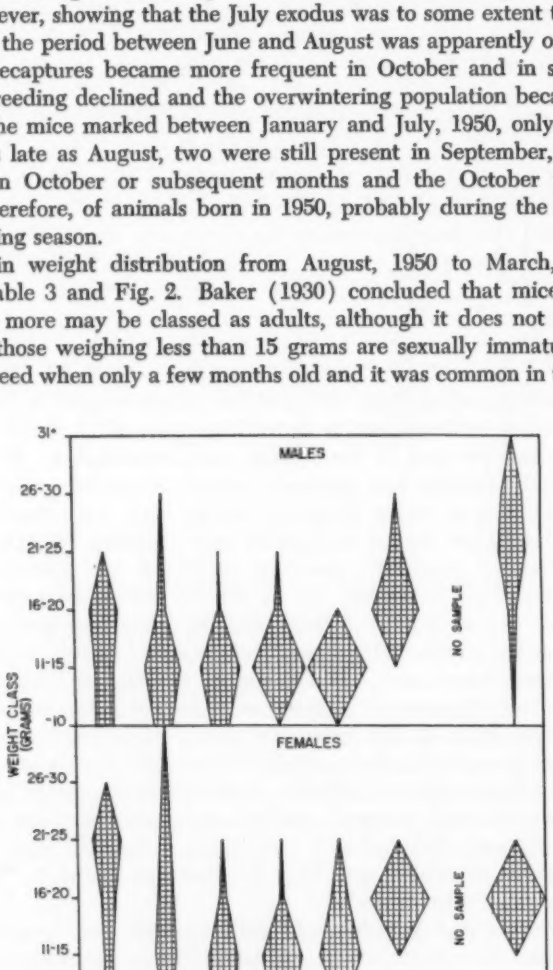

FIG. 2.—Weight distributions of male and female *Apodemus* from August, 1950 to March, 1951.

TABLE 3.—*Weight distribution and age structure of population from August, 1950 to March, 1951*

MONTH	N	– 10 gm.	11–15	16–20	21–25	26+
Males:						
1950						
Aug.	7	28.6%	28.6%	42.8%		
Sept.	31	25.8	58.1	12.9	3.2%	
Oct.	27	33.3	63.0	3.7		
Nov.	20		90.0	10.0		
Dec.	5		100.0			
1951						
Jan.	20			80.0	20.0	
Feb.						
Mar.	16		6.2	12.5	43.8	37.5%
Females:						
1950						
Aug.	13	15.4	15.4	23.1	46.1	
Sept.	17	17.6	35.3	29.4	11.8	5.9
Oct.	17	41.2	47.1	11.8		
Nov.	25	32.0	64.0	4.0		
Dec.	3		66.7	33.3		
1951						
Jan.	19			100.0		
Feb.						
Mar.	13		7.8	92.9		

study to find pregnant or lactating females that weighed 15 grams or less; the smallest lactating female weighed 12.0 grams and one 7.5-gram animal had a perforate vagina. Nevertheless, 15.0 grams seems to be the most convenient dividing point between adult and immature mice, and the data in Table 3 and Fig. 2 describe the trends in age distribution that occurred in the overwintering mouse population.

The August and September populations were composed of animals from a wide range of age groups, but with a greater proportion of females than males in the adult age classes. By October the proportion of older mice had decreased until there were no males or females in the 21–25 gram class and very few in the 16–20 gram class. From November onwards there was a gradual shift in weight distributions to successively heavier weight classes; all of the mice captured in December weighed more than 11 grams and all of those captured in January weighed over 16 grams, although the weights of the males were distributed over a wider range of classes than were those of the females.

d. *Seasonal abundance.*—The values for the number of mice per 100 trapnights in column 3 of Table 2 were obtained by first subtracting the number of traps occupied by voles or shrews from the total of 82 trapnights and using

the remaining number of available trapnights to calculate values for *Apodemus*. It was assumed, in other words, that the voles and shrews pre-empted traps that might otherwise have been occupied by mice, thereby reducing the number of possible trapnights for *Apodemus*. The values for "known population" were obtained by adding the number of mice trapped in a sample to the number also known, through subsequent captures, to be in the study area. For example, if a mouse was marked in March and was subsequently captured in May but not in April, it was included in the known population for all three months. This presumes of course that the animal did not leave the trapping area, or that immigration and emigration were balanced. The values for density in column 5 are based on the known population relative to the 5.3 acres covered by the trapping grid, rather than the actual area of the copse.

The high turnover of individuals from May through September made it difficult to estimate mortality rates or population density during that period; estimates obtained with the Lincoln Index method were considered unreliable and not particularly useful. It is felt, however, that the values for known population are a reasonably reliable index to abundance, in spite of the fact that they are minimum values. The known population density varied from 3.6 mice per acre in May to 10.9 per acre in November, with a mean of 6.1 per acre for the total period of study, if we disregard the density of 1.3 per acre in July, since this was apparently an unusual situation. Brown (1954) reported an average density of 8.5 per acre during an 18-month period with a maximum of 17.2 per acre in November, in a comparable study of *Apodemus* populations. His results showed a sharp increase between September and November and an overwintering decline from November until the following breeding season. The data from the present study show a similar trend; the lowest population density was reached at a time when the breeding season had begun and juveniles were replacing adults in the population. The rate of breeding and replacement was sufficient to maintain a fairly steady density of about four mice per acre until August. Between August and November there was a sharp increase in density, followed by an overwintering decline to approximately the same density that was observed in the preceding spring.

The critical density for small mammal populations is usually reached in

TABLE 4.—*Frequency of recaptures*

POPULATION	NUMBER OF TIMES CAPTURED 1	2	3	4	5	6	TOTAL
Males:							
Number	61	19	13	5	4	1	103
Per cent	59.2	18.4	12.6	4.8	3.9	1.0	
Females:							
Number	54	17	11	6	3	0	91
Per cent	59.3	18.7	12.1	6.6	3.3		

spring when the adult population must be large enough to provide the replacement rate that is necessary in order for the population to survive a high summer mortality and to establish a new and vigorous overwintering population (Leslie and Ranson, 1940; Elton, 1942). *Apodemus* populations are not especially erratic in their density variations from year to year and it would appear that they have achieved a remarkably close adjustment to the forces of natural control. They are capable of a high rate of increase, and yet overpopulation does not seem to be a feature of their ecology.

TABLE 5.—*Average monthly distances moved, based on the distance between the point of capture for the month shown and the last previous point of capture*

MONTH	MALES		FEMALES	
	Number of individuals	Average distance (yards)	Number of individuals	Average distance (yards)
1950				
Jan.				
Feb.				
Mar.	6	34.5	6	46.2
Apr.	7	55.1	8	31.2
May	5	88.0	10	29.8
June	2	81.5	4	30.8
July				
Aug.			3	15.0
Sept.	3	96.0	2	25.0
Oct.	7	47.9	7	17.0
Nov.	12	20.8	8	20.0
Dec.	4	28.2	2	46.0
1951				
Jan.	17	33.5	12	15.2
Feb.				
Mar.	14	31.1	10	24.8

3. Population activity patterns.

As Elton, *et al.* (1931) point out, most census techniques measure combined changes in both the density and activity of a population. Changes in the activity rhythm and in the spatial patterns of activity of a species are invariably reflected in trapping data, and it is essential that these changes and their effects be accounted for. Moreover, it is also important to establish which of the observed activity changes are regular, seasonal phenomena and which are unpredictable in the sense that they are not correlated with normal, seasonal variations in physical and biotic factors.

a. *Recapture rate.*—The frequency of captures of males and females is shown in Table 4. A comparison of the percentages of males and females captured from one to six times shows no significant differences between the sexes; thus 40.8 per cent of the males and 40.7 per cent of the females were

recaptured and the maximum number of captures was six for one male and five for three females, even though the males usually moved greater distances during the intervals between samples.

b. *Seasonal variations in movement.*—Table 5 shows the average distances moved during the year; these values are averages of the distance moved by each individual between the point of capture for the month shown and the last previous point of capture. In most cases the interval between captures was one month but in others the interval may have been as much as three months. Although the varying length of these intervals is a possible source of error, there was no correlation between the distance moved by an individual and the length of the interval between captures. These data are illustrated in Fig. 3.

The average distance moved by females did not fluctuate greatly during the year; there seemed to be a slight decrease in activity as the breeding season progressed, but this trend was not pronounced. The increase shown for December was based on the movements of only two animals and is not reliably significant. The activity of the males, however, showed striking and rather consistent changes. The average distance moved was more than doubled between March and May, 1950, and long movements continued from May until September. Following September there was a decrease to an average distance of about 20 yards per individual in November and a slight increase from November to January and March, 1951, when the average distances

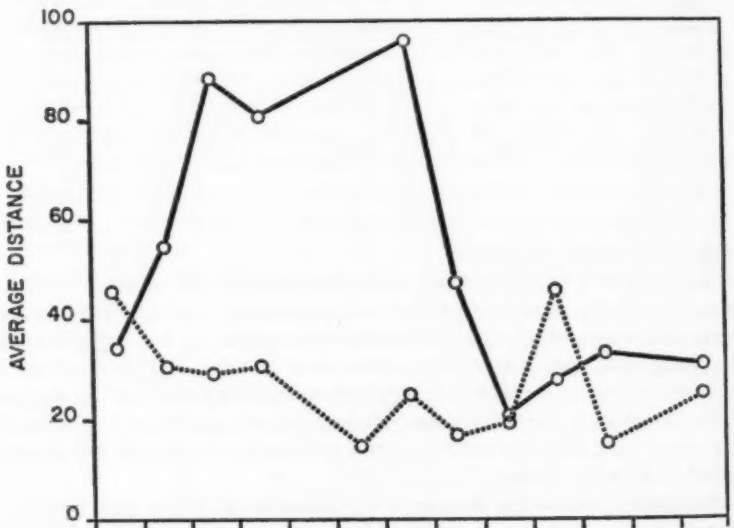

FIG. 3.—Average distance (yards) moved between the month shown and the last previous capture. Males, solid line; females, dotted line.

TABLE 6.—*Observed range lengths and home ranges of A. sylvaticus captured three or more times*

OBSERVATION OF		MALES	FEMALES
Range length (yards):	Mean	66.5 ± 9.75	38.4 ± 5.24
	Range	(11.0–187.0)	(5.0–88.0)
Home range (yards²):	Mean	3471.5	1157.5
	Range	(95.0–27450.7)	(19.6–6079.0)
Home range (acres):	Mean	0.72	0.24
	Range	(0.02–5.67)	(0.004–1.26)

were nearly equal to those recorded for March, 1950. Even though these values are based on rather small samples, the observed changes are so pronounced that they suggest a definite, seasonal trend. The changes in the activity patterns of the males occurred during the breeding season but did not coincide with the breeding condition of the males; by March, 1950, all the males had apparently begun reproductive activity, although the height of the female season did not occur until May. The most obvious correlation is with the breeding condition of the females; when the average distance moved by males increased from 34 yards in March to 55 yards in April, the percentage of females in breeding condition increased from 44.4 to 75.0 per cent. By May, 90 per cent of the females were breeding and the distances moved by males had increased to an average of 88 yards. During the period when male activity remained high the reproductive activity of the females was also high and as the percentage of reproductive females decreased from about 70 per cent in September to 12 per cent in October, and breeding finally ceased in November, the average distances moved by the males decreasd from 96 yards in September to 48 yards in October, and finally to a low value of about 21 yards in November. While further research is needed before this apparent corelation can be established as a causal relationship, it does suggest that the breeding condition of the females might possibly control the activity patterns of the males as well as the reproductive cycle of the population.

c. *Home range and observed dispersal.*—Of the various methods for measuring and calculating home range that have been described, the "Observed Range Length" method is the most applicable to these data. This method assumes that the distance between the most widely separated capture sites is equivalent to the diameter of the home range. Although Stickel (1954) has shown that the "Adjusted Range Length" method, in which half the distance to the next trap site is added to the observed range length, is more accurate, it and many other available methods cannot be used with these data because of the practice of using random rather than fixed trap positions.

The average observed range lengths and calculated home ranges for mice captured three or more times are shown in Table 6. Brown (1956) studied the movements of *Apodemus* and reported average observed range lengths

of 64.6 yards for males and 57.6 yards for females; corresponding values from the present study are 66.5 ± 9.75 yards for males and 38.4 ± 5.24 yards for females. Using Manville's (1949) method for calculating trap-revealed range, Brown obtained values of 3092 yards square for male and 2628 yards square for female home ranges; home ranges calculated from observed range lengths in the present study were approximately 3472 yards square for males and 1158 for females. Thus the data obtained by Brown (1956) for male *Apodemus* are roughly comparable to these, but his values for females are considerably higher.

Davis (1953) has discussed several reasons for using the frequency distribution of distances between captures in the analysis of small mammal movements. While this method cannot be used to establish the home range of an individual and is perhaps less useful than most other methods for the analysis of home range as such, it does provide a useful index to the nature of the movements of a population and avoids some of the difficulties inherent in other methods. Table 7 shows the observed values for frequency of capture at different distances and an adjusted frequency distribution based on the probability of capture at each interval of distance. As shown in column 6, there is a curve of increasing and decreasing probability of capture with increasing distance; in most cases this will be a normal curve (Davis, 1953), but the curve for these data is skewed and slightly bimodal because of the shape of the trapping grid. There was a marked increase in the probability of capture between the intervals

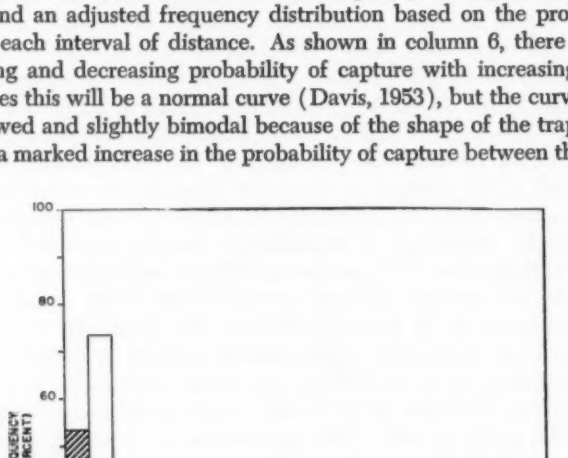

FIG. 4.—Adjusted frequency distribution of number of movements at each interval of distance shown.

TABLE 7.—*Frequency of capture at different distances*

DISTANCE (yards)	OBSERVED FREQUENCY				PROBABILITY OF CAPTURE, %	ADJUSTED FREQUENCY	
	Males		Females				
	N	%	*N*	%		Males, %	Females, %
0–20	22	28.6	35	48.6	4.1	53.3	73.4
21–40	28	36.4	24	33.3	10.8	25.7	19.1
41–60	11	14.3	7	9.7	15.2	7.2	4.0
61–80	7	9.1	4	5.6	14.0	5.0	2.5
81–100	4	5.2	2	2.8	16.6	2.4	1.0
101–120	2	2.6			13.1	1.5	
121–140	1	1.3			11.6	.8	
141–160					7.7		
161–180	2	2.6			4.8	4.1	
181–200					2.1		
201+					0.0		

of 0 to 20 yards and 21 to 40 yards, and a gradual decrease in probability at distances greater than 100 yards. There were no opportunities for capture at distances of 200 yards or more.

The adjusted frequency distributions shown in Table 7 and Fig. 4 show a strong tendency for females to restrict their movements to short distances. Males were captured with a frequency of 53.3 per cent and females 73.4 per cent at distances between 0 and 20 yards and 86.2 per cent of the movements by males and 96.5 per cent of the movements by females were restricted to distances of 60 yards or less. In each case there is a strongly descending frequency curve with increasing distance, showing that a very large proportion of the movements of both sexes were confined to rather short distances; but none of the females moved more than 100 yards whereas more than 6 per cent of the movements recorded for males were of distances greater than this.

In order to compare the results of different studies, using the frequency distribution method of analysis, the data from each study must be converted to adjusted frequencies based on probability of capture. Since the data reported for comparable species have not included this adjustment such comparisons cannot be made at present. It should perhaps be emphasized that an observed frequency which is not adjusted for probability of capture has very little meaning; it is especially biased for movements of short distances (Davis, 1953) and does not account for the effects of different distances between trap sites or the size and shape of the trapping grids. The same is true for home range values; differences in method affect the results, and the significance of a value for home range depends on the degree of which it represents the behavior of the total population.

Davis (1953) noted that his data included dispersal as well as home range

movements and the same is undoubtedly true of the data shown in Table 7. This problem has also been noted by other workers. Brown (1956), for example, states that "stay at homes" as well as "wanderers" were present in the populations he studied and that both contributed to the wide range in the types of movement he examined. He also found, however, that 73 per cent of the mice moved less than 30 yards, 92 per cent less than 60 yards and that 96 per cent moved less than 90 yards from one day's trapping to the next. He found no evidence that any of the mice had moved to new positions within their home ranges or had adopted new home ranges during any single trapping period. Evans (1942) recorded the movements of 194 *Apodemus* that survived for a month or more on his trapping plots in Bagley Woods and found that only 75 per cent confined their movements to distances of 100 yards or less and that movements of over 400 yards occasionally occurred. He recorded one case in which a distance of 240 yards was covered in one day. It would appear from the latter study that rather long movements are more common than might be supposed from the data presented by Brown and the present study, although the data do not show which of the movements were dispersal and which were home range.

If we consider the shape of the curves shown in Fig. 4, and the fact that 86.2 per cent of the males and 96.5 per cent of the females moved less than 60 yards during the entire period of study, it becomes obvious that the occasional long movements that were recorded had a disproportionate effect on the size of the calculated home ranges. This fact is also evident in the results presented by Brown (1956); 92 per cent of the population moved less than 60 yards between trappings, yet the average home ranges were calculated to be 64.6 yards square for males and 57.6 yards square for females. It appears, therefore, that the home ranges given in both of these studies are overestimates of the true home range, since they are based on dispersal as well as home range movements.

At least three typical patterns of movement can be distinguished in recapture data, as illustrated by selected examples in Fig. 5. Typical home range patterns were shown by two mice (No. 419♂ and 498♀) that confined all of their movements to well-defined areas. A second pattern is shown in the movements of two mice (No. 342♂ and 12♀) which were initially captured at points some distance from the areas of most of their captures; these mice apparently dispersed to new home ranges between their first and second captures and subsequently stayed within their new home ranges during the remainder of the observations. The male (No. 342) moved 163 yards between August and September and then moved 40, 15, 17 and 15 yards between subsequent captures. The female (No. 12) moved 100 yards between the time it was marked in January and its second capture in March; it then moved 43 yards between March and April, 32 yards between April and May, and by September when it was last captured it had only moved 22 yards from where it was taken in May. This pattern, with several possible variations, would appear to represent a combination of dispersal and home range movements; it is the sort of pattern that might be shown when animals are crowded out of one area and into another or when they are attracted to a new

home range by more favorable factors such as food supply or shelter. A third pattern is illustrated by two males (No. 11 and 34) which invariably moved rather long distances between each capture. Number 11 was first trapped in the Pasticks in March, 1950, and was captured again in April, about 170 yards from its initial capture-site, in a copse south of the study area. By May it had returned to the Pasticks, 90 yards from its second point of capture, having moved across a plowed field and back again in its travels. Number 34 likewise showed a pattern of relatively long movements of 61, 45, 132 and 102 yards between its inital capture in January, 1950, and its last capture in June. This third pattern of apparently aimless wanderings seems to represent a continued series of dispersal movements. In this study it was only shown by adult males during the breeding season and is perhaps best explained as a search by unmated males for breeding females and a nest site.

Thus the following types of movement seem to be included in these data: (1) home range, (2) home range + dispersal and (3) dispersal. An example of the error that can be introduced into home range values by including dispersal movements in the calculations is shown by a comparison between the calculated home ranges and range lengths of animals 32 and 12 before and after eliminating

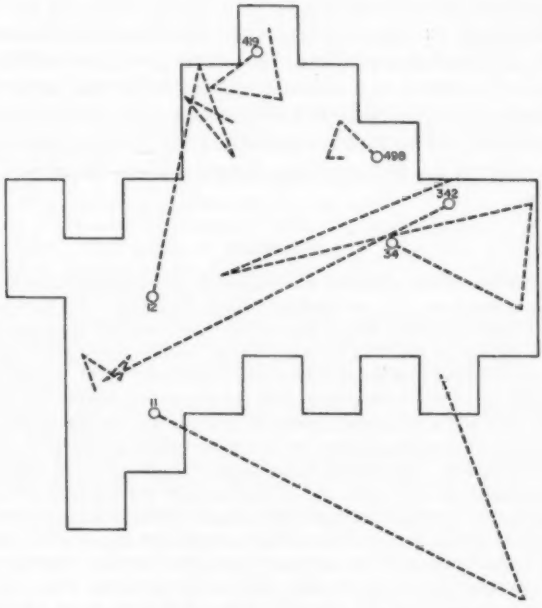

FIG. 5.—Selected examples of patterns of movement. The ring number of each individual is shown beside a circle indicating its initial point of capture; dotted lines connect subsequent points of capture.

dispersal movements from the data. If we consider that the first movements of each animal were dispersal, the following values for all movements (*a*) and home range movements only (*b*) are obtained:

ANIMAL NO.	AVERAGE DISTANCE MOVED	OBSERVED RANGE LENGTH	HOME RANGE (yds.^{2})	HOME RANGE (acres)
32 (*a*)	50.0	147.5	17101.8	3.53
(*b*)	21.8	21.5	350.4	0.07
12 (*a*)	49.2	102.5	8247.5	1.70
(*b*)	32.3	40.0	1256.0	0.26

Although no attempt has been made to treat all of the data in this way, it is obvious that the results would be far different if such treatment could be consistently applied. As yet there is no objective method for distinguishing between home range and dispersal in recapture data. Davis (1953) noted an empirical relationship between frequency of capture and distance, such that a straight line results when this relationship is plotted on double logarithm paper. "A mathematical model that represents this relation is $fr^x=c$, or $\log f + x \log r = \log c$, which is a straight line of negative slope x" (Davis, 1953). In this expression, f represents frequency of capture, r represents distance and c is a constant. This line descends and bends sharply toward the r axis ($f=0$), so that the value of r at the bend might be related in a constant manner to the size of the home range. The data necessary to generalize this relationship have not been collected, but there is an obvious need for further research on this problem and for establishing an objective method for distinguishing between home range and dispersal in recapture data.

SUMMARY

A population of *Apodemus sylvaticus* was studied by live-trapping from January, 1950, to March, 1951, in a five-acre copse in Wytham Woods, Berkshire. The 1950 breeding season extended from March to October with a peak in May, and the 1951 breeding season began in January. The early start of the 1951 breeding season is attributed to abundant food supplies and, possibly, to a relatively high population density in the fall of 1950. Except for a temporary migration of mice out of the study area in July, the population reached its lowest density of 3.6 per acre in May and a maximum density of 10.9 per acre in November, and the overwintering population that was established by November consisted entirely of mice born during the 1950 breeding season. The average home range of males captured three or more times was 3742 yards square, or 0.72 acres, and of females 1158 yards square, or 0.24 acres. The average distances moved each month by females were relatively constant, but males moved far greater distances during the period from May to September than at other times of the year. This increased activity seemed to be correlated with the breeding condition of the female population. Three types of movement were noted in the recapture data: (1) home range, (2) home range + dispersal and (3) dispersal. Although there is, as yet, no objective method for distinguishing between home range and dispersal from recapture data, the latter is extremely important in the activity patterns of the population and influences estimates of home range considerably.

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LITERATURE CITED

BAKER, J. R. 1930. The breeding season in British wild mice. Proc. Zool. Soc. Lond., 96: 113–126.

BAKER, J. R. AND R. M. RANSON. 1932*a*. Factors affecting the breeding of the field-mouse (*Microtus agrestis*). Part I—Light. Proc. Roy. Soc. Lond., 110B: 313–332.

———. 1932*b*. Factors affecting the breeding of the field-mouse (*Microtus agrestis*). Part II—Temperature and food. Proc. Roy. Soc. Lond., 112B: 39–46.

BROWN, L. E. 1954. Small mammal populations at Silwood Park Field Center, Berkshire, England. Jour. Mamm., 35: 161–176.

———. 1956. Movements of some British small mammals. Jour. Anim. Ecol., 25: 54–71.

CHITTY, D. 1937. A ringing technique for small mammals. Jour. Anim. Ecol., 6: 36–53.

CHITTY, D. AND D. A. KEMPSON. 1949. Prebaiting small mammals and a new design of live trap. Ecology, 30: 536–542.

CROWCROFT, P. 1954. The daily cycle of activity in British shrews. Proc. Zool. Soc. Lond., 123: 715–729.

DAVIS, D. E. 1953. Analysis of home range from recapture data. Jour. Mamm., 34: 352–358.

ELTON, C. 1942. Voles, mice and lemmings. Clarendon Press, Oxford, 496 pp.

ELTON, C., J. R. BAKER, E. B. FORD AND A. D. GARDNER. 1931. The health and parasites of a wild mouse population. Proc. Zool. Soc. Lond., 95: 657–721.

EVANS, F. C. 1942. Studies of a small mammal population in Bagley Wood, Berkshire. Jour. Anim. Ecol., 11: 182–197.

LESLIE, P. H. AND R. M. RANSON. 1940. The mortality, fertility, and rate of natural increase of the vole (*Microtus agrestis*) as observed in the laboratory. Jour. Anim. Ecol., 9: 27–52.

MANVILLE, R. H. 1949. A study of small mammal populations in northern Michigan. Misc. Publ. Mus. Zool., Univ. Mich., No. 73, pp. 1–83.

MATTHEWS, L. H. 1952. British mammals. Collins, London, 410 pp.

MILLER, R. S. 1954. Food habits of the wood-mouse (*Apodemus sylvaticus*) and the bank vole (*Clethrionomys glareolus*) in Wytham Woods, Berkshire. Saugetierkundliche Mitteilungen, 2: 109–114.

———. 1955. Activity rhythms in the wood mouse, *Apodemus sylvaticus* and the bank vole, *Clethrionomys glareolus*. Proc. Zool. Soc. Lond., 125: 505–519.

SNEDECOR, G. W. 1956. Statistical methods. The Iowa State College Press, Ames, Iowa. 5th ed., 534 pp.

STICKEL, L. F. 1954. A comparison of certain methods for measuring ranges of small mammals. Jour. Mamm., 35: 1–15.

TANAKA, R. 1951. Estimation of vole and mouse populations on Mt. Ishizuchi and on the uplands of southern Shikoku. Jour. Mamm., 32: 450–458.

Univ. of Saskatchewan, Saskatoon, Canada. *Received June 8, 1957.*

THE FUR AND MOLTS IN THE SHREW, *MYOSOREX CAFER*

By J. Meester

A series of *Myosorex cafer* (Sundevall) from Western Pondoland contains specimens in various stages of molt. As nothing is known about seasonal pelage changes in *M. cafer* or any other species of Southern African shrew, the present paper will discuss the fur and fur changes of this series.

Materials and methods.—The material studied consists of 64 skins of *M. cafer* from Port St. Johns and Ngqeleni districts, Western Pondoland. Frequency distribution of this material over the different months appears in Table 1.

In studying this series each specimen was examined in order to detect signs of fur change, and to ascertain the manner and extent of this, when present. Furthermore, approximate length of the contour hairs was measured on the back of the rump, along the dorsal midline. Mean, minimum and maximum monthly values for hair length were obtained where possible, and these values are presented in Table 1. Mean values are further plotted in Fig. 1. No values are available for March and October, and those for January, November and December are based on single specimens.

Similar values were obtained for two further measuring points along the dorsal midline, viz., between the shoulders and halfway between the fore and hind legs. As variation in these values closely resembles that in hair length on the rump, the data for these two measuring points are not included in the present discussion.

Observations.—The color of the back in the present series is dark brown, grizzled with buffy. Along the sides color becomes gradually paler, while the belly is paler still, buffy brown with a gray tinge. Hands and feet are brown, and the tail is dark brown above, gradually becoming slightly paler down the sides and below. Short, pale gray hairs, closely applied to the skin surface, mark the lateral glands. These are present in all but two of 45 males, and all but four of 19 females. When present they vary in degree of development and appear to be more strongly developed in males than in females.

Some slight seasonal variation exists in color; summer specimens appear slightly darker and more blackish on the whole than those taken in winter.

The fur of the back is composed mainly of contour hairs, interspersed with long, scattered guard hairs which occur mainly on the rump. On the belly guard hairs are absent. Individual contour hairs of the back have a long slaty base, varying from about 4 to 8 mm. in length, followed by a short buffy band, about 1 to 2 mm. long, and a dark brown tip about as long as the buffy band. Hair length decreases from the rump forward, so that while the hair on the rump may attain a maximum length of about 12 mm., on the shoulders maximum hair length is about 9 mm. On the snout the hair is even shorter, with a maximum length of about 5 mm. at the level of the eyes.

The contour hairs of the belly are shorter than those of the back, with a slaty-gray base about 2 to 4 mm. long, followed by a buffy tip, about 2 mm. in length.

TABLE 1.—*Monthly variation in the length of the contour hairs on the back of the rump in a series of Myosorex cafer from the Port St. Johns and Ngqeleni districts, Western Pondoland; measured on the dorsal midline*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
N:	1	2	0	5	11	6	22	12	3	0	1	1
Min:	–	7.5	–	7.1	6.6	6.9	6.9	9.3	9.0			
Max:	–	7.9	–	9.1	10.7	11.8	11.0	10.8	10.6			
M:	8.6	7.7	–	8.1	8.9	10.1	9.9	10.0	9.8	–	7.7	7.5

Maximum length is about 6 mm. Little variation in length occurs over most of the ventral surface, between the fore and hind legs. Further forward the hair becomes progressively shorter on the throat and on the chin, where maximum length is only about 3 mm.

The guard hairs of the back are about half as long again as the contour hairs, with the buffy and dark brown bands longer in proportion to the slaty-gray base than is the case in contour hairs.

Seasonal variation in length of the contour hairs on the rump is as follows (Table 1 and Fig. 1):

During the period from May to September the hair is long, mean hair length varying from 8.9 to 10.1 mm. The highest mean value is attained in June. A sharp decrease in hair length takes place around October (from 9.8 to 7.7 mm.).

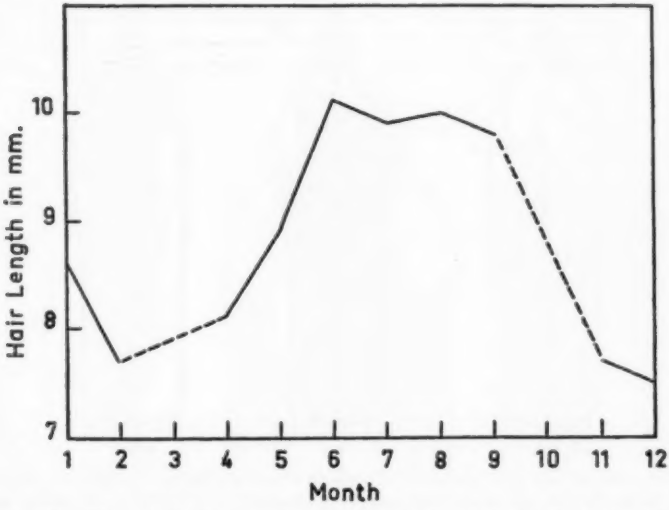

FIG. 1.—Monthly variation in mean length of the contour hairs on the back of the rump in a series of *Myosorex cafer* from the Port St. Johns and Ngqeleni districts, Western Pondoland; measured on the dorsal midline.

During the months from November to April the hair is fairly short, mean values varying between 7.5 and 8.6 mm.

Two specimens show signs of a spring molt. These are TM 830♀, collected on August 30, 1910, and TM 820♀, collected on August 28, 1911. A diagrammatic representation of the extent of fur change in these specimens appears in Fig. 2.

In TM 820 the change has just started, new hairs having appeared in a narrow zone on the snout, in the region of the eyes, and is proceeding backward. In TM 830 it is practically completed, the only parts where the old pelage is still present being part of the sides and the rump and the extreme back of the ventral surface, behind the anus. In this animal, too, the change is therefore proceeding in a posterior direction. The new fur in both specimens is about 2 to 3 mm. shorter than the old and a distinct line of separation between old and new fur is visible as a consequence of this difference in length. In TM 830 the new coat is distinctly darker than the old. This is not the case in the other specimen.

In thirteen specimens, collected between November 10 and July 10, signs of a fall molt were detected. In these specimens hardly any external sign of change is apparent, as the old and new coats are virtually indistinguishable in color or length. The new fur is in fact shorter and usually more dense than the old, but these differences are small and can only be detected by detailed observation and measurement.

What appears to be the usual course of fur change is diagrammatically repre-

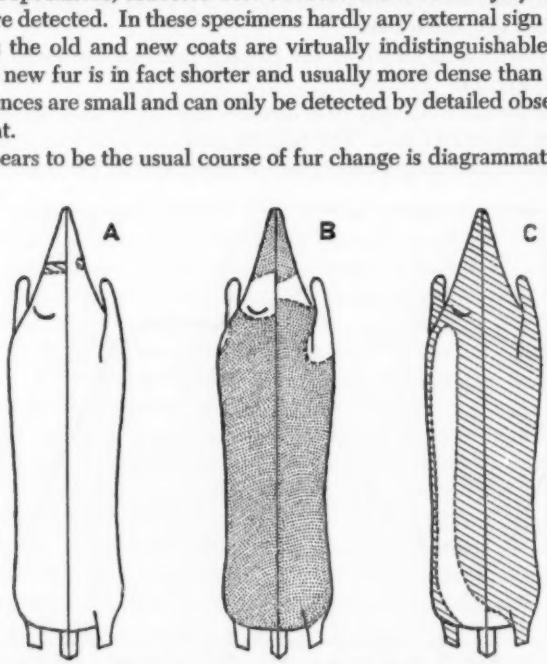

FIG. 2.—Diagramatic representation of molt in three specimens of *Myosorex cafer* from Port St. Johns district, Western Pondoland. *A*, spring molt in TM 820♀; *B*, spring and fall molt in TM 815♂; *C*, spring molt in TM 830♀. Dorsal surface portrayed on the left, ventral surface on the right. Hatching represents summer fur and dots the new winter fur. Old winter fur unshaded.

sented in Fig. 3. Change starts on the rump (*A*), then proceeds more or less evenly forward along the back, and also backward along the back of the rump, then forward along the ventral surface (*B*). The dorsal wave of change then spreads down the sides (*C*) and meets the one proceeding forward along the ventral surface (*D*). The hind legs are now encircled by a zone of change which proceeds in the direction of the feet. In the meantime, the change continues forward, faster along the back and more slowly along the belly. When the dorsal wave reaches the head it spreads over the head and down its sides to the chin and throat. Here it meets the ventral, which has advanced meanwhile to more or less the level of the forelegs and throat (*E*). When the two waves meet the legs are encircled basally by a zone of change (*F*) which proceeds down the forelegs in the direction of the feet, to complete the molt.

The change proceeds more or less symmetrically, although at times molt on either the left or the right side of the body may be more advanced. There is also some variation in the relative speeds at which the dorsal and ventral waves progress. For example, in TM 801♂, collected on May 23, 1909, the change has progressed over practically the whole of the dorsal surface, while on the ventral surface only a small area on the belly has changed, and a spot under the chin, about 1 cm. in diameter, is in the process of changing. In TM 815, on the other hand, molt has progressed to the throat ventrally while dorsally it has not yet reached the ears, and is consequently not as far advanced as ventrally. At the same time a separate zone of change has encircled the snout and is proceeding backwards (Fig. 2, *B*). Most of the specimens examined, however, on the whole support the description given above.

Discussion and conclusions.—The exact course of the spring change could not be inferred from the available material. Both specimens showing this molt

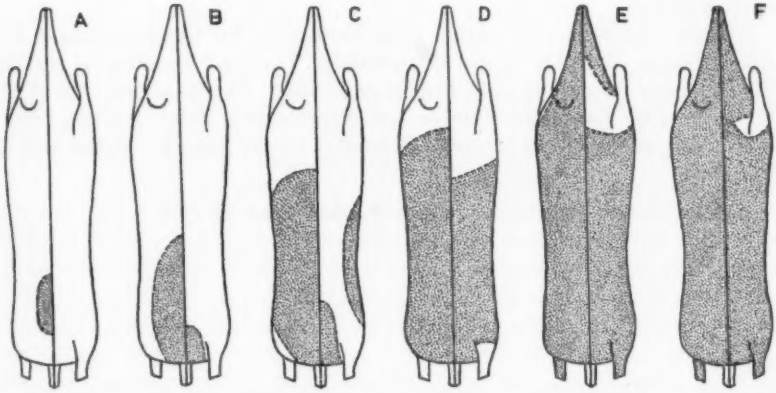

FIG. 3.—Diagrammatic representation of fall molt in *Myosorex cafer* from the Port St. Johns and Ngqeleni districts, Western Pondoland. See text for details. Dorsal surface portrayed on the left, ventral surface on the right. Dots represent winter fur.

suggest, however, by the distribution of the new fur relative to the old, that change proceeds in a posterior direction. The new fur is considerably shorter than the old, and the sharp decrease in average hair length on the rump around October is probably a consequence of the reduction in hair length occasioned by the spring change. The new fur may be darker than the old, but this need not be the case.

The time at which the spring molt takes place varies somewhat. The decrease in hair length around October suggests that most individuals molt during this period. However, both specimens actually undergoing molt (TM 820 and TM 830), were collected late in August. It is therefore likely that the spring molt may occur at any time from August to October, or may extend over even a longer period.

Hamilton (Jour. Mamm., 21: 457–458, 1941) stated that in over a thousand specimens of *Blarina brevicauda* (Say) examined by him, the spring molt was seen in specimens taken between March 23 and August 4, therefore ranging over a period of nearly five months.

After the spring molt the fur remains fairly short until April, when there is an increase in hair length. This increase continues until June, after which hair length remains more or less constant until the next spring molt, starting around August.

The fall molt differs from the spring molt in not being externally visible and in that the new fur does not differ noticeably from the old in color or length. Also, the fall molt proceeds forward from the rump, and not backward from the snout, as does the spring molt.

Specimens showing the fall molt were taken from November 10 to July 10. The period during which this change can take place must therefore extend at least from early November to mid-July. This is much longer than the spring molting period.

Acknowledgments.—The author wishes to express his sincere thanks to Dr. J. T. Robinson, of the Division of Palaeontology, Transvaal Museum, for reading this paper and for making many helpful suggestions. Thanks are also due to the Directors of the Kaffrarian Museum, Kingwilliamstown, Natal Museum, Pietermaritzburg, and National Museum, Bulawayo, for the loan of material used in this study.

Transvaal Museum, Pretoria, South Africa. *Received March 22, 1957.*

HABITS OF THE SHORT-TAILED SHREW IN CAPTIVITY

By John P. Rood[1]

Although *Blarina brevicauda* is one of the commonest mammals in eastern North America, relatively few studies have been made of its habits. The shrew's secretive manner and habit of working under cover make field observations impractical and scientists have long held the false belief that this is a difficult species to keep in captivity. The purpose of this paper is to add to the existing meager knowledge of the short-tailed shrew by an analysis of its habits and behavior under various conditions of captivity.

Acknowledgments.—I am indebted to Dr. William H. Burt for his suggestions and critical reading of the manuscript. I also wish to thank Mr. Frank Hinds, Dr. Oliver P. Pearson and all the others who helped to make the project possible.

Methods.—Twenty shrews, twelve males and eight females, were live-trapped in Kalamazoo, Michigan, from October 19 to December 31, 1956. Seven died in the traps in spite of the fact that these were checked every four hours throughout the day. Of the thirteen that survived, seven were males and six were females. Four were caught in a grassy field, three in a leaf pile, eleven in a hardwood forest and two in a large meadow near a small stream. Most of the shrews were taken in or near their tunnels, often under the snow.

Immediately following capture, the shrews were sexed, weighed and marked with No. 1 bird bands placed on the hind legs. They were anesthetized, in about two minutes, with 40 drops of ether. A slight pressure with the thumbs, on both sides of the anal opening of males, brought the penis into view. On capture, the females averaged 16.5 grams and the males 18 grams, but most of the shrews tended to gain weight in captivity.

The shrews were placed in various types of terraria, some containing several inches of soil and others with only enough soil to cover the cage floor. When soil was provided they immediately began to dig and soon had the earth honeycombed with tunnels. When sods or other kinds of cover were placed in the cages, the shrews slept under them, but frequently no cover was provided and they were forced to sleep in the open.

General observations.—The short-tailed shrew moves with a jerky running motion. In strange surroundings it moves cautiously, sniffing constantly, and keeping close to the sides of the cage, but it soon learns its way about and runs freely. The shrew's eyesight is very poor, and it gives no evidence of being able to distinguish objects. A pencil moved about in front of one brings no response unless the animal is actually touched. Likewise, the sense of smell is not well developed, although shrews constantly twitch their noses and thoroughly sniff any strange object they happen to encounter. They are unable to find a mealworm at a greater distance than three inches, and frequently a shrew will pass within an inch of a mouse without detecting it.

[1] Recipient of an honorarium in 1957 for this paper.

The sense of hearing is acute, however. These shrews are able to detect slight sounds at a distance of several feet. There is no response to the human voice but the click of a flashlight will send a freshly caught shrew racing for cover. After a few days in captivity, they become accustomed to most of the common household sounds and are no longer alarmed by them.

Probably the senses of touch and vibration are the most highly developed of all. They always showed immediate response when touched or lightly breathed upon, or when the cage was disturbed. One large male became very tame and took mealworms and other live food from the fingers. He slept underground but came running to the surface whenever the cage was opened.

Temperature is an important factor in influencing the shrew's periods of activity, and it is more likely to be out in warm than in cold weather. Pearson (1947) stated that in his experience shrews were trapped more readily in the daytime in winter and at night in summer. Most of my shrews were caught in the daytime since the evening temperature frequently dropped below freezing. In captivity, at a stable temperature of 70°F., the shrews were most active in the early morning, although they were liable to be out at any time of the day or night. In general, they were active for only a few minutes at a time, although an individual once remained active for 98 minutes, from 3:45 to 5:23 A.M.

Leaves and grass were provided as nesting materials. These were sometimes dragged into a corner, but were often ignored. If the cage was supplied with soil, the shrews usually enlarged one of their tunnels and used this as a sleeping chamber, but occasionally they slept above the ground in a cage corner.

These animals have several sleeping positions. Usually the nose and front paws are tucked beneath the belly. The shrew often varies this by sleeping with head outstretched, turning on its side, or even on its back with all four legs in the air. In the latter position the tail is curled over the belly and the back of the head rests on the ground. The animal is constantly turning about in its sleep and seldom keeps the same position for more than a few minutes at a time. It frequently wakes up to yawn, stretch and clean itself before dozing off again. If several friendly individuals are kept in the same cage, they sleep curled up together, often atop one another. Each tries to burrow underneath the pile, resulting in a constant changing of position. Whenever a shrew approaches the pile, he burrows underneath the others, waking them and starting a scramble for the most comfortable positions.

The shrew cleans itself frequently, usually after each period of activity. Most of the cleaning is done with the nose, but rapid motions of the hind feet are used to clean the neck and sides. The small pink feet are thoroughly licked with the tongue, and the nose and face are brushed with slow forward motions of the front feet.

Blossom (1932) recorded that his *Sorex* sometimes played with an insect in much the same manner that a cat plays with a mouse. My shrews seemed to get a good deal of enjoyment from pushing against one another and snuggling together. A solitary shrew often turned somersaults and rolled about after

waking from sleep, sometimes making barely audible squeaks while so engaged. Some shrews apparently derived pleasure from licking the screen sides and top of their cage. One grasped the top with his front claws and licked the screen for minutes at a time before finally dropping to the ground.

Contrary to popular belief, captive short-tailed shrews are surprisingly hardy. They seem to do equally well in various types of cages of all sizes. One large male lived in a cage with a floor space of 20 × 2 in. for several days and remained in excellent health in spite of the cramped quarters. Likewise, shrews lived for months in cages with no cover and very little soil. When transferred from trap to cage the shrews made themselves right at home and soon began to eat and behave in an apparently normal manner. Naturalists differ on the reason for the frequent deaths of shrews in live traps, and many attribute these to the animal's nervousness. As short-tailed shrews are very hardy under adverse conditions of captivity, many of these trap deaths may be a result of exposure.

Voice.—These little mammals make a wide variety of sounds which seem to represent their various emotions. The commonest of these is a sharp, high-pitched squeak of annoyance or anger. When first caught in a trap, or if otherwise greatly enraged, some shrews utter a shrill, penetrating shriek that can be heard for a considerable distance. One freshly caught male, when annoyed, threw back his head and sent forth a loud, bird-like chatter that lasted for about ten seconds. When slightly disturbed, some shrews whimper softly. Similar to this, but somewhat higher pitched, is a series of barely audible, rapid squeaks which sound like the twittering of a sleepy sparrow. This is apparently a sign of contentment or inquiry and is made when the shrew is eating a favorite food, cleaning itself, arranging nesting material, or investigating a strange object.

When fighting, shrews make a wide variety of squeaks, trills and chatter. If two unfriendly or strange animals meet, they sniff noses and each opens its mouth and gives a loud squeak. If one does not retreat, both begin to utter series of rapid squeaks and trills. Sometimes they go into a clinch so that the squeaks have a muffled quality. A most peculiar sound is a series of rapid, unmusical clicks, which sound a little like the chatter of teeth. Pearson (1944) said this sound was made by a male courting a female; however, my shrews seemed to use it as a warning or challenge. When two aggressive males were confined together, one approached the other and made this peculiar chatter, whereupon the latter retreated. This sound was also heard from a pile of sleeping shrews and was followed by the breaking up of the pile and sometimes a brief scuffle.

Digging habits.—With its small eyes, pointed snout, strong front feet and streamlined body, the short-tailed shrew is well adapted for a fossorial existence and is an accomplished digger. To observe the shrew's method of digging, I constructed a narrow glass case, with sides 2 feet long, 1 foot high, and an inch apart. In this cage, a shrew could move only in one plane and could not hide its tunnels. The cage was filled to a depth of 6 inches with densely packed sandy loam, and a large male was placed inside. After running about the surface for a

few minutes, he started digging straight down at one end of the cage, with powerful motions of his front feet working alternately. When a load of loose soil accumulated behind him, it was kicked to the surface with the hind feet. As he dug deeper, he was forced to back up the tunnel kicking dirt to the surface with his hind feet. When enough dirt had accumulated at the surface, the shrew pushed and smoothed it out with his pointed nose.

After digging a few inches vertically, the shrew began a horizontal tunnel by angling toward the center of the cage. When a load of dirt accumulated behind him, he turned, by means of a sideward somersault, and pushed the dirt to the end of the horizontal tunnel with his nose. Then he continued on to the surface losing most of the dirt on the way; turning around, he dug down again, throwing the already loosened dirt to the surface with his hind feet. Whenever a pebble was encountered, it was grasped firmly in the mouth and tugged to the surface to be deposited at the tunnel entrance. By this procedure the shrew completed, in a few hours, a tunnel the length of the cage with surface entrances at each end. The actual digging time was about an inch a minute, but the shrew stopped frequently for short naps.

The shrew was kept in this small cage for a month, during which he dug several new tunnels and plugged the old ones. Others placed in the cage varied in their digging ability. While some dug long horizontal tunnels the length of the cage, others made only short vertical tunnels and spent most of their time at the surface.

Food habits.—There are numerous accounts of short-tailed shrews eating two or even three times their weight in a day, and most authorities apparently believe that this animal has an enormous appetite. Seton (1909) said: "Numerous experiments and observations on captive animals prove that the Blarina, like its smaller kin, has an enormous appetite which must be satisfied or in a very few hours the creature succumbs." Nelson (1918) remarked while speaking of *Blarina*: "Like other shrews and the moles, their digestion appears to be very rapid and they will eat two or three times their own weight in a day." On the other hand, Hamilton (1930) said on this subject: "My observations with several shrews carried on for an entire spring convince me that one half the shrew's weight in food is ample for it over a 24 hour period, and more often than not, only one half of this much is daily eaten." My results agree with Hamilton's in that the shrews ate an average of less than half their weight in a 24-hour period. Because of this, I believe that most of the accounts of *Blarina's* appetite have been overdrawn; perhaps some people have confused them with *Sorex* in this respect.

The shrews showed a preference for live food, but if this was not available, they readily accepted a wide variety of substitutes. Their daily diet consisted of a mixture of ground beef, horsemeat, walnuts, sunflower seeds, and rolled oats. In addition they frequently ate earthworms, mealworms (both larvae and adults), dead shrews, dead birds, mice, chicken, canned dog food, peanuts, crackers, whole wheat bread, and cheese. They were always kept supplied with

food and water. The shrews showed a great deal of individuality in their food preferences as well as in their behavior patterns. Two of their favorite foods were walnuts and Ritz crackers, and these were always among the first to be eaten. Most of the animals readily ate dead shrews placed in their cages, but one male always refused to turn cannibal unless no other food was provided.

A shrew lifts its head when eating and drinking, apparently to facilitate swallowing. It carries small bits of food to its nest, but meat and other large articles are eaten in the open. While eating, the shrew never sits on its haunches like a mouse, but remains in the normal position with all four feet on the ground. Nuts and seeds are usually steadied with the front feet while the animal is gnawing on them.

Authorities disagree on the extent to which the short-tailed shrew preys upon mice. Shull (1907) found a *Blarina* nest composed entirely of mouse hair with three *Microtus* carcasses, and the legs and tails of twenty others, nearby. Eadie (1944, 1948) found mouse remains in 56 per cent of *Blarina* scats during a period of high mouse abundance and 14 per cent in a low period. These results seem to indicate a relatively high rate of predation, but Hamilton (1930, 1941) found mouse remains in only 3 per cent of *Blarina* stomachs analyzed, and concluded that shrews are not as important in mouse control as had been thought.

My shrews showed great individual differences in their interest in catching *Peromyscus*. Even when in very small cages, some would not attack a mouse. Pearson gives me the following interesting information on shrew individuality in a recent letter: "I can remember when I was taking movies of shrews killing meadow mice. I wasted yards of film on one *Blarina* that was terrified every time the mouse came near it; another one made only half-hearted attacks, and a third attacked so fast and so viciously that I missed most of the action." Pearson also reports a *Blarina* and *Peromyscus* that lived amicably together in the same cage and slept curled next to each other.

In no case could the shrews catch a *Peromyscus* in a cage where the mouse had room in which to maneuver. In cages with a floor space of 20 × 12 in., the mouse could always avoid the shrew and never was caught. One mouse that lived for a week with two shrews showed visible fear only if the latter were squeaking at each other. It let a shrew approach and touch its nose, but the mouse was always able to jump away if the shrew made a lunge at it. Sometimes one of the shrews chased the mouse, but it was always too quick and agile to be caught. Another shrew seemed afraid of a deer mouse. If the mouse raised itself on its hind legs in a defensive position, the shrew gave a squeak and ran down its tunnel.

In a cage with a floor space of 20 × 2 in., a mouse lived happily with three shrews. Sometimes one of the shrews became annoyed with the mouse and gently bit it, but the mouse never seemed to mind this treatment. It was not afraid to climb atop the sleeping shrews, and frequently slept close to them.

In another instance, a deer mouse placed with a young male shrew, in this same small cage, was immediately attacked and eventually killed. As soon as

the mouse entered the cage, the shrew grabbed and bit it several times in a brief scuffle. The mouse broke loose for a moment, but was instantly grasped near the base of the tail, and for the next few minutes the mouse dragged the shrew about the cage, desperately trying to break loose. The shrew then grabbed the mouse by the back and went into another flurry of biting at its head and midsection. The mouse tried in vain to bite the shrew, apparently unable to break through its skin. By this time the mouse was exhausted and could put up only token resistance. Whenever it seemed to be free of the shrew, the little assassin attacked it in a more vital spot. When the mouse was too weak to resist any longer, the shrew dragged it about the cage by the head and then began to bite into its skull just behind the ear. Although the mouse was still alive, the shrew continued to eat it for 5 minutes before the mouse ceased to breathe and the gory drama was at an end. The whole episode lasted about 30 minutes and was characterized, as are all these battles, by silence. The mouse did not make a noise throughout, and the shrew gave only an occasional, barely audible twitter of excitement.

The procedure for eating a mouse varies with the individual shrew. Usually the brains are eaten first; then the shrew progresses on to the tail, eating the bones as well as the flesh. Occasionally this results in a skin neatly turned inside out, but more often than not the skin is bitten through in several places. Sometimes the shrew starts eating at the shoulder and leaves the head intact. It never eats the head of a bird, but starts at the anal opening and progresses to the neck, leaving the head untouched.

Because of the shrew's inability to catch a *Peromyscus* in anything but a very small cage, it seems unlikely that it preys on these mice in the wild. Possibly an occasional mouse might be trapped in a tunnel, or a nest of young found and devoured.

Social behavior.—Naturalists have long believed that shrews are strictly solitary animals except for a short period preceding mating. Merriam's well-known experiment of placing three *Sorex* under a tumbler, whereupon one killed and ate the other two in the course of a few hours, has become practically a classic in this field. Pearson (1944), who has probably done as much work with *Blarina* as anyone, says regarding its sociability: "Two shrews will seldom live amicably in the same cage unless they have been raised together from birth."

I experimented with several combinations of shrews and, in most cases, they lived peaceably together with only occasional quarrels. Their social success seemed to depend primarily on individual dispositions with age and sex playing a lesser role.

One observation concerned a male and two females which were placed together in a large cage with numerous sods for shelter and enough soil to cover the cage floor. These shrews were all caught within 50 feet of each other and were judged to be quite young, weighing between 14 and 16 grams each. When placed in the cage they ran about excitedly, sniffing the ground and generally keeping to the cage sides. When two came together they opened their mouths,

gave a loud squeak and jumped away. During the next week the shrews always slept under separate sods and frequently fought over the best sleeping places. If one invaded another's sod, he was usually repelled by loud squeaks from the indignant owner but, if the intruder persisted, a brief scuffle took place beneath the sod. Usually the original owner was left in possession, but occasionally the male succeeded in displacing one of the females. After a week of this behavior, the male and one of the females were sometimes found curled together under the same sod. Soon all three were sleeping together and, although there were still occasional quarrels, they seemed to enjoy each other's company and frequently nuzzled one another.

When the shrews had been together about three weeks, another female, trapped in a completely different region, was added to the group. Usually she was ignored by the original three unless she tried to sleep with them; then she was repelled by loud squeaks from one of the females. Nevertheless, the new shrew continued to try to burrow into the pile and, after four days of sleeping separately, she was finally accepted and all four slept together.

One day a large male was placed in the cage where the four shrews were asleep in the corner. When he investigated the pile, the four shrews immediately began sniffing about. Soon all five animals were excitedly running about the cage. When one of the females met the strange male, she squeaked and jumped away but, if the two males met, the stranger chased his smaller opponent. Sometimes they went into a clinch and rolled about the ground, squeaking angrily and biting each other on head and body. The battle ended with the smaller male breaking loose and running away, while the stranger turned on his back. After a few of these skirmishes the smaller male avoided his bigger rival, which was removed before either was seriously hurt. Both shrews had lost chunks of fur from their midsections but otherwise seemed to be uninjured.

One of the females was removed and two adult shrews, a male and female, were added to the remaining group making a total of two males and three females. At first the original shrews slept together, while the new male and female slept in separate corners. The shrews seemed to recognize each other by sniffing noses. If the original animals met, in the course of their daily activity, they touched noses and went their separate ways. Should the new shrews meet each other, or one of the original three, each would open its mouth and give several loud squeaks, whereupon a brief scuffle was likely to occur. After a few days the five began to mingle with each other so that any combination of sleeping shrews was possible. Soon they were all sleeping together in the same corner, and this continued throughout their period of captivity.

Fights were rare in this group once the shrews became accustomed to each other. The new male and female were more pugnacious than the original three and sometimes quarreled over favorite tidbits, especially nuts and crackers. Each guarded his morsel by leaping at any other shrew that threatened it and by carrying it to another part of the cage if the intruder persisted. Sometimes, however, a shrew succeeded in grabbing another's tidbit and making off with it

before the rightful owner knew what had happened.

Mating was attempted on December 31, between the original male and one of the original females. However, the female was unreceptive and fought him off with loud squeaks. Twice he mounted her back and grasped the scruff of her neck with his teeth, but she broke loose each time. The male did not persist, and shortly afterwards both shrews went to sleep together.

After the shrews had been together about three weeks, one of the original females became sick. She had great difficulty in moving and could do so only with a slow, wobbly motion. The others left her strictly alone and did not attack or bother her in any way. After death she was left untouched, although shrews normally are quick to eat dead of their kind.

Males placed together in small cages varied in their inclination and ability to fight. Some pugnacious individuals immediately went into a clinch, while others of a more docile nature usually ignored each other. One small shrew could usually cause his larger opponent to retreat by leaping at it and uttering a piercing shriek whenever the larger animal approached. Two large and quarrelsome males lived together for 15 days in a large cage with plenty of cover. They fought frequently over a favorite nest box and never slept together as friendly shrews usually do. Finally one was mortally wounded in one of the many battles.

An adult male and female, placed together in a large cage in late afternoon, proved to be particularly quarrelsome. They commenced fighting almost immediately with loud squeaks, chatter and frequent clinches. Each took up residence under a separate sod; if one approached the other's sod the intruder usually was repulsed with loud chatter. If it persisted, a fight occurred underneath the sod and one of the shrews was forced to retreat. The fighting continued most of the evening; on the following morning the female was dead and partly eaten.

Because of the marked individual differences in the dispositions of short-tailed shrews, it is difficult to make generalizations about their social behavior. However, the males did seem to be more quarrelsome than the females, and the young less so than the more mature individuals. Those that were quick to kill and eat a mouse also seemed to be more pugnacious with their own kind. The majority of my shrews got along quite well together and, while the short-tailed shrew cannot be considered a particularly sociable animal, I doubt that it is as solitary as is generally believed.

SUMMARY

Thirteen short-tailed shrews were trapped alive in Kalamazoo, Michigan, from October 19 to December 31, 1956. They proved to be very hardy under all conditions of captivity. Observations were made on their senses, activity times, sleeping posture, cleaning habits, voice and digging habits. The shrews ate a wide variety of foods. They were unable to catch *Peromyscus* except in very small cages and, even then, some would not attack a mouse. When a mouse was killed, it took the shrew about 30 minutes to complete the task. Several shrews could be kept in the same cage with only occasional quarrels. As many as five, of both sexes, lived amicably with each other and slept curled together in piles. Males in small cages usually

fought among themselves, but two could live together if the cage was large enough. In general, young shrews and females were less pugnacious than adult males. The shrews showed marked individual differences in many aspects of their behavior.

LITERATURE CITED

BLOSSOM, P. M. 1932. A pair of long-tailed shrews (Sorex cinereus cinereus) in captivity. Jour. Mamm., 13: 136–143.

EADIE, W. R. 1944. The short-tailed shrew and field mouse predation. Jour. Mamm., 25: 359–364.

———. 1948. Shrew-mouse predation during low mouse abundance. Jour. Mamm., 29: 35–37.

HAMILTON, W. J., JR. 1930. The food of the Soricidae. Jour. Mamm., 11: 26–39.

———. 1941. The food of small forest mammals in eastern United States. Jour. Mamm., 22: 250–263.

NELSON, E. W. 1918. Smaller mammals of North America. Natl. Geogr. Mag., 33: 371–493.

PEARSON, O. P. 1944. Reproduction in the shrew (Blarina brevicauda Say). Amer. Jour. Anat., 75: 39–93.

———. 1947. The rate of metabolism of some small mammals. Ecology, 28: 127–145.

SETON, E. T. 1909. Life histories of northern animals. Scribner's, N.Y. Vol. 2: 1116–1135.

SHULL, A. F. 1907. Habits of the short-tailed shrew, *Blarina brevicauda* (Say). Amer. Nat., 41: 495–522.

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MAINTENANCE, REPRODUCTION AND GROWTH OF THE LEAST SHREW IN CAPTIVITY

BY C. H. CONAWAY

Published accounts describe the nest and young of various species of shrews. Usually such young are of unknown ages, so that little information about growth and development is available. Similarly, little information is available concerning breeding and gestation periods of most soricids. Some observations upon reproduction and growth of *Cryptotis* have been made by Hamilton (1944) and Walker (1954). Additional information about growth, reproduction and behavior, obtained from a laboratory colony of *Cryptotis parva*, is given here.

Maintenance in captivity.—During September, 1956, a laboratory colony of *Cryptotis parva* was established with 11 animals captured in sunken tin cans. The animals were maintained under conditions found satisfactory for soricids by other workers (Rudd, 1953; Crowcroft, 1951; Pearson, 1950). They were kept in 10- and 15-gallon aquaria with an inch of wood shavings and dry soil added to cover the bottoms. When wood shavings alone were used the fur became oily but this was prevented when soil was included. A handful of dry leaves and grass was provided for nest material and a small open container was used for water.

Water was provided at all times and relatively large quantities were consumed by the shrews. Only meat was fed to the animals. Fresh, entire or ground rat, mouse or bird carcasses were the staple food. On some occasions frozen horse meat was used and this proved successful if supplemented with liver. A diet of liver alone, however, was unsatisfactory and resulted in rapid deterioration of the animals. The colony has now been maintained for nine months.

Four to six animals of both sexes were kept in each cage. No difficulty was experienced in keeping several individuals together if they were all placed in the cage at the same time. This species is remarkably social in behavior. No aggressive action was observed among individuals living in established community cages. On several occasions when a new shrew was introduced into a cage where shrews were resident, immediate conflict resulted. This was so violent that the newcomer was removed to prevent injury. More often, however, new shrews were added to established cages without trouble.

The behavior of the captive animals was very uniform. A community nest was constructed in one corner and used by all individuals in the cage. Bone and fur scraps were incorporated into the nest. Another corner, usually at the greatest possible distance from the nest, was used as a common latrine. All individuals adapted very well to captivity and they were not timid or easily disturbed by handling.

Breeding, gestation and care of the young.—Copulation was observed on seven occasions. The general pattern of copulatory behavior was similar to that described by Pearson (1944) for *Blarina*. In two instances copulation was known to occur over two days and in the remainder it was observed only on one day. Parturition was never observed, although the time of birth was known within six hours for five litters. All of these births occurred during the afternoon. Five known gestation periods varied between 21 and 23 days from the date of last mating. These data are summarized in Table 1.

A post-partum estrus and breeding occurred in one of three females which were in cages with males after the young were born. In this instance five young were born during the afternoon of March 1, copulation was observed during the afternoon of March 3, and a second litter of four young was born March 24.

Three litters were born to females that were in cages with two to five other adult animals of both sexes. All adults exhibited considerable maternal behavior. One of these litters, born in a cage containing six adult animals, survived only for five days. Loss of this litter apparently resulted from starvation. The large number of adults crowded into the nest and the disturbance caused by them apparently prevented nursing. A second of these litters was born in a cage containing four adults. When the nest and young were intentionally scattered, all four adults participated in caring for the young and rebuilding the nest. Immediately after disruption of the nest the adults ran about carrying young and placing them in various areas of the cage. Another adult often picked up the same young animal and carried it elsewhere. Several times two adults picked up the same young simultaneously. Much tugging and pulling then occurred until

TABLE 1.—*Gestation periods of Cryptotis*

BREEDING DATE	PARTURITION DATE	GESTATION (days)	NO. YOUNG
Oct. 8 and 9	Nov. 1	23	6
Dec. 5	Dec. 28	23	5
March 3	March 24	21	4
March 26	April 16	21	5
March 29–30	April 20	21	5

finally one animal gained possession of the young. Soon the animals became less disturbed and moved all young to the site of the old nest. They then quickly reassembled the nest. Apparently the young were unharmed by the rough handling, for the entire litter survived. A third litter was successfully reared by a female caged with two other adults.

Young *Cryptotis* were confined to the nest until day 16 to 18. During this period the mothers were aggressive and attempted to bite whenever the young were handled. After day 10, young shrews which were removed from the nest for examination usually crawled away from the nest when replaced in the cage. The mother immediately carried them back to the nest. By day 18 the young were permitted to leave the nest. They began to feed upon meat during brief excursions from the nest, but they continued to nurse occasionally until day 21 or 22. Because quantities of food were carried into the nest by the mother during the second and third week it is not known when the young first began to eat meat.

Growth of young.—Weight curves were obtained by randomly selecting an individual from a litter each day and recording its weight. Although only one young from a litter was weighed each day as routine procedure, occasionally more were weighed to obtain variability. The available data are summarized in Fig. 1. Growth was extremely rapid and by day 21 weights ranged between 3.2 and 4.3 gm. It appears that the maximum growth rate occurred between days 6 and 10. Between days 10 and 17 the growth rate declined. An increase began about day 18 and extended to day 24. Just prior to weaning, the total mass of a litter was approximately three times that of the mother. At this time the young may not receive an adequate food supply. Metabolic rates begin to increase rapidly in the young after day 10, indicating that more food per unit weight would also be required (unpublished data). These factors may account for the decreased growth rate prior to weaning, and may stimulate the young to start eating meat.

Body weight increases to 4 or 4.5 grams within a few days after weaning. It then declines, probably because of the increased activity which is apparent at this time. Data from two litters which were weighed through day 50 indicate that the body weight fluctuates considerably through this period but it remains below the post-weaning peak weight. The data of Johnston and Rudd (1957) suggest that a similar decline occurs in *Sorex vagrans*.

Young *Cryptotis* develop very rapidly. The newborn young have been described by Hamilton (1944). During the first two days there is little change in appearance. By day 3 the dorsum begins to darken and crawling movements are observed. On day 4 the nose and chin are conspicuously pigmented. The dorsum is very dark on day 5, and the following day hair becomes visible. Hair on the side glands is very prominent on day 7. During the next few days the young become fully haired. At the end of the second week their eyes are open and the young appear similar to adults except that they are smaller and have the silvery immature pelage.

Discussion.—Captive *Cryptotis* are remarkably social animals exhibiting no obvious aggressive behavior in established community cages. Because of this, and the ease with which they may be bred and maintained in captivity, they seem best adapted among the common soricids for use as a laboratory animal. Various reports indicate that this species is also quite social in the wild. The

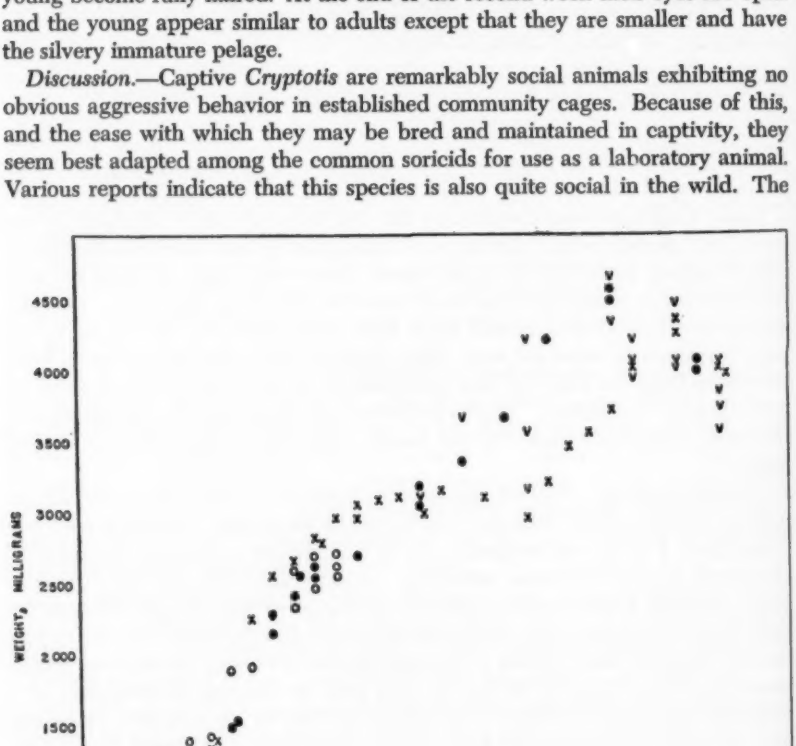

FIG. 1.—Body weight of *Cryptotis* from birth to day 30.

finding of two or more adult *Cryptotis* together or in the same nest has been reported by several workers (Hamilton, 1934; Davis and Joeris, 1945; Hunt, 1951; Broadbooks, 1952; Connor, 1953). Davis and Joeris (1945) report finding 12 adult individuals in a single winter nest. In several cases an adult male and female have been taken at a nest containing young (Hunt, 1951; Broadbooks, 1952). Evidence of cooperative behavior in digging was noted by Davis and Joeris (1945).

Although *Cryptotis* seems more social than most soricids, it is also possible that much of the aggressive behavior and cannibalism reported in various species of shrews is the result of observations made upon ill-kept and starved animals. *Sorex vagrans* may be kept easily under conditions similar to those described here for *Cryptotis* (personal observation). A few other workers have kept various shrews in groups (Rudd, 1953; Dehnel, 1952). Dehnel (1952) indicates that the male *Sorex araneus* will participate in rearing young.

The general pattern of reproduction and development in *Cryptotis* is similar to that reported for other genera. Pearson (1944) found that in *Blarina* mating occurred over two to five days. The length of gestation measured from the first mating was 21 to 22 days and 17 to 20 days from the last mating. *Cryptotis* was not observed to mate over more than two days. The gestation period is 21 to 23 days from the last mating. Dehnel (1952) gives the gestation period of *Sorex araneus* as 20 days. The gestation period of *Crocidura leucodon* is 31 to 33 days (Frank, 1953).

One case of a true post-partum pregnancy is known to have occurred in the *Cryptotis* observed in this study. It also appears that this may have occurred in the colony kept by Walker (1954). He gives the gestation period of *Cryptotis* as between 12 and 16 days. Apparently his evidence for such a short gestation period is that in four instances a female gave birth, raised her young and gave birth again in 24 days while in three instances this interval was 22 or 23 days. If these are interpreted as post-partum rather than post-lactation pregnancies (as Walker seems to consider them) gestation would then be within the range reported in this study. Pearson (1944) did not observe a post-partum estrus in captive *Blarina* but Hamilton (1949) indicates that it occurs in wild populations. Crowcroft (1955) reports the occurrence of a post-partum estrus in captive *Sorex araneus*. Indirect evidence indicates that it frequently occurs in wild *Sorex araneus* (Brambell, 1935), *Sorex minutis* (Brambell and Hall, 1937), *Sorex palustris* (Conaway, 1952), *Sorex fumeus* and *Sorex cinereus* (Hamilton, 1949), *Sorex trowbridgei* (Jameson, 1955) and *Sorex vagrans* (Johnston and Rudd, 1957).

The weight curve given in this study is in agreement with limited data reported by Hamilton (1944). These data differ considerably from the weights reported by Walker (1954). He gives the weight on the first day as 15 grains (972 milligrams). Other figures reported are correspondingly high. It can only be concluded that the data given by Walker (1954) are probably unusual. Perhaps the litter weighed was not discovered until several days after birth.

SUMMARY

Information about the maintenance and behavior of *Cryptotis parva* in captivity is given. This species is well adapted to captivity and it shows much less aggressive behavior than is reported for other soricids. Gestation is 21 to 23 days from the last observed copulation. A post-partum pregnancy was observed in one of three females which were with males after giving birth to a litter. *Cryptotis* are weaned after 21 days. A weight growth curve is given.

LITERATURE CITED

BRAMBELL, F. W. R. 1935. Reproduction in the common shrew (*Sorex araneus* Linnaeus). Phil. Trans. Roy. Soc. Lond., B, 225: 1–62.

——— AND K. H. HALL. 1937. Reproduction of the lesser shrew (*Sorex minutus* Linnaeus). Proc. Zool. Soc. Lond., 1936: 957–969.

BROADBOOKS, H. E. 1952. Nest and behavior of a short-tailed shrew, *Cryptotis parva*. Jour. Mamm., 33: 241–243.

CONAWAY, C. H. 1952. Life history of the water shrew (*Sorex palustris navigator*). Amer. Midl. Nat., 48: 219–248.

CONNOR, P. F. 1953. Notes on the mammals of a New Jersey pine barrens area. Jour. Mamm., 39: 227–235.

CROWCROFT, P. 1951. Keeping British shrews in captivity. Jour. Mamm., 32: 354–355.

———. 1955. Notes on the behavior of shrews. Behavior, 8: 63–80.

DAVIS, W. B. AND L. JOERIS. 1945. Notes on the life-history of the little short-tailed shrew. Jour. Mamm., 26: 136–138.

DEHNEL, A. 1952. The biology of breeding of the common shrew (*S. araneus*) in laboratory conditions. Ann. Univ. Mariae Curie Sklodowska. Lublin-Polonia. Sec. C, 6:359–378 (Translated from Polish by M. Milonski).

FRANK, F. 1953. Beitrag zur Biologie, insbesondere Paarungsbiologie der Feldspitzmaus (*Crocidura leucodon*). Bonner Zool. Beit., 4: 187–194.

HAMILTON, W. J., JR. 1934. Habits of *Cryptotis parva* in New York. Jour. Mamm., 15: 154–155.

———. 1944. The biology of the little short-tailed shrew, *Cryptotis parva*. Jour. Mamm., 25: 1–7.

———. 1949. The reproductive rates of some small mammals. Jour. Mamm., 30: 257–269.

HUNT, T. 1951. Breeding of *Cryptotis parva* in Texas. Jour. Mamm., 32: 115–116.

JAMESON, E. W., JR. 1955. Observations on the biology of *Sorex trowbridgei* in the Sierra Nevada, California. Jour. Mamm., 36: 339–345.

JOHNSTON, R. F. AND R. L. RUDD. 1957. Breeding of the salt marsh shrew. Jour. Mamm., 38: 157–163.

PEARSON, O. P. 1944. Reproduction in the shrew (*Blarina brevicauda* Say). Amer. Jour. Anat., 75: 39–93.

———. 1950. Keeping shrews in captivity. Jour. Mamm., 31: 351–352.

RUDD, R. L. 1953. Notes on maintenance and behavior of shrews in captivity. Jour. Mamm., 34: 118–120.

WALKER, E. P. 1954. Shrews is shrews. Nature Mag., 47: 125–128.

Dept. of Zoology, Univ. of Missouri, Columbia. Received June 29, 1957.

BLEACHING OF HAIR PIGMENT IN BATS BY THE ATMOSPHERE IN CAVES

By Denny G. Constantine

The treatment of "color phases" in mammals ranges from mere acknowledgment that they exist to descriptions of new species and subspecies. Probably some atypical coat colors are genetic (Storer and Gregory, 1934); others apparently result from fading (Constantine, 1957). Andersen (1917) demonstrated that three "color phases" of *Rhinolophus rouxi* (Temm.), previously described as separate subspecies, were in reality identical, except that the dark "subspecies" was in fresh pelage and the two successively lighter-colored "subspecies" were in progressively faded or "oxidized" pelage. He suggested that an "oxidizing element" was responsible for the color of the lighter-colored bats. Stager (1942) noted that a massive group of *Tadarida* at Ney Cave in Texas was composed of approximately 50 per cent apparently typical *Tadarida brasiliensis mexicana* (Saussure) of both sexes and 50 per cent atypically light-colored female bats. Absence of specimens showing intergradation led him to suspect that the light-colored bats represented an undescribed species. A comparison indicated that the light-colored form averaged larger than the dark form, and it was described as *Tadarida texana*. During August, 1944, when collections of *T. b. mexicana, Myotis velifer incautus* (J. A. Allen), and *Mormoops megalophylla senicula* (Rehn) were made in caves in Texas, the author became aware that the pelage of many specimens was atypically light in color. Thereupon, a study was undertaken, including additional collection of specimens and field data, age analyses, and studies in color variation and molt periods and patterns. Evaluation of these data indicated that, at least in *Tadarida* and *Myotis*, considerable color fading follows growth of the new coat; but in the presence of ammonia gas and water vapor in caves, the hair pigment is apparently bleached to a remarkable extent. The bleaching effect of ammonia and water vapor has been tentatively confirmed by a laboratory experiment.

RESULTS

Collection of specimens and field data.—As conditions permitted, trips were made to several caves where, in addition to general observations and specimens, the following types of data were collected: estimates of bat aggregations; distribution of bats within caves; temperature and relative humidity of cave rooms; guano distribution and consistency; abundance and distribution of dermestid beetles (*Dermestes carnivorus* F.); and ammonia gas concentrations.

Frio Cave, 9 miles south of Concan, Uvalde County, Texas was visited August 16–27, 1944; December 12 and 17, 1946; July 1–27, 1948; April 29–30, 1952; and November 28, 1955. Study skins and live specimens were prepared and examined as follows: *Tadarida*, 188 skins, 2628 live; *Myotis*, 227 skins, 418 live; *Mormoops*, 62 skins, 246 live.

The entrance of this limestone cave opens into a large chamber, room 1, which opens on one side into a smaller chamber, room 2. *Tadarida* found refuge in rooms 1 and 2, where the cave floor was covered by a thick carpet of relatively dry guano. Room 2 communicates with another small chamber, room 3, by a low passageway and another chamber, room 4, communicates with room 3 by a similar passageway. Rooms 3 and 4 were refuges for *Mormoops* and *Myotis* respectively, and were characterized by a wet carpet of guano.

Tadarida, when present, were estimated in the millions, and an impressive *Tadarida* flight occurred each evening. Room 1 and a wide fissure just inside the cave entrance were irregularly occupied by *Tadarida* on all visits excepting April, when no bats were in room 1, and November, when no *Tadarida* were found in the cave. Room 2 was occupied by numbers of *Tadarida* on all but the November trip. This room contained primarily young *Tadarida* in July. By July 12, adult females were well on the way to establishing a peculiar habit which may be natural, or may have been influenced by human intrusions. Whereas they had previously occupied room 2, on that afternoon most of them were in room 1 and a lesser number were suckling young bats in room 2. Throughout the afternoon adult females moved constantly between these rooms nourishing the young bats. On July 13, 97 *Tadarida*, too young to fly, were banded in room 2. As these bats became capable of flight, they joined the adult females in room 1, although only a dozen could later be accounted for.

In August and December room 3 contained an estimated three to four thousand *Mormoops*. This species was not observed in July or April, but was present in similar numbers in room 4 in November. *Mormoops* were never captured in nets at the cave entrance, although *Tadarida* and *Myotis* were regularly captured in this manner during evening flights.

In April, July and August *Myotis* were present in room 4. In November, three *Myotis* were found hibernating in the fissure, just inside the cave entrance, but none was observed elsewhere and none was found in the cave in December. In July and August the *Myotis* aggregation was estimated to be about 9,000. In April it was estimated to be 20,000. The ceiling on one side of room 4 slanted gradually downward until it left an irregularly defined one- to two-inch horizontal space above the guano. Thousands of *Myotis* occasionally retreated through this space, indicating that another space lay beyond.

During summer dermestid beetles and their larvae infiltrated and blanketed the relatively dry guano beneath *Tadarida* clusters. The presence of the beetles was associated with scant to overpowering concentrations of ammonia in proportion to the size of the beetle population. Dermestids and ammonia appeared beneath *Tadarida* clusters each time the bats changed cave quarters. Only a slight odor of ammonia and a few beetles were found in winter. The guano floors of rooms containing *Myotis* and *Mormoops* were quite wet and no dermestids and lower concentrations of ammonia were present. In April, when ammonia was only slightly detectable to the olfactory sense, air samples from room 2 showed an ammonia content of 0.017 vol. per cent.

In July the temperature in room 1 was 71°F. and each room was successively warmer until the temperature was 86° in room 4. At 11:00 PM on July 13, when most of the adults had left the cave for the evening flight, the temperatures of these rooms were one to three degrees cooler than at 1:00 PM that afternoon. Probably the lowered outside temperature had an influence, but absence of the heat radiated by the bats themselves is believed to be the primary factor in lowering the temperatures of the cave rooms. In December the rooms were four to twelve degrees cooler. Relative humidity was between 82 and 100 per cent, the dampest atmosphere being that of room 4.

Ney Cave is another limestone structure, situated 20 miles north of Hondo in Medina Co., Texas. It was visited August 15, 1944, and May 1, 1952, when 1460 live *Tadarida* were examined. The cave contained at least two large bat chambers situated at different levels. The guano floor varied in moisture content from dry to muddy. In August the multimillion *Tadarida* aggregation was accompanied by a huge dermestid population and ammonia fumes were overpowering. The cave was not visited in winter but reports of other workers and residents indicated that bats could not be found in the cave in winter. In May millions of bats were judged to be present, but relatively small numbers of beetles were seen and the light ammonia concentration was measured at 0.014 vol. per cent. On September 10, 1940, Glen Kohls (personal communication) recorded the temperature and relative humidity in a side compartment of this cave; the readings were 84°F. and 84 per cent. In May the temperature in the lower bat chamber was 70°F. and the relative humidity was 77 per cent.

Lower Eagle Creek Cave, located about 7 miles south of Morenci Pump Station, Greenlee Co., Arizona, was visited July 30, 1948, and April 27, 1952. Thirteen *Tadarida* were prepared as skins, and 175 live bats were examined. This sandstone cave possesses one bat chamber, about 110 feet long, 40 feet wide and 40 feet high. The floor is covered by dry guano. This room communicates with the entrance through a passageway approximately 40 feet in height, 15 feet in width and 40 feet in length. In July, ammonia fumes were quite strong and the dermestid population was large. The cave temperature was 94°F. and the relative humidity was 26 per cent, compared with outside readings of 94°F. and 23 per cent. No ammonia was detected in April, when only one dermestid beetle was observed. The cave temperature was 50°F. and the relative humidity was 69 per cent, probably because of the prevailing rainy weather. On both visits the active *Tadarida* aggregation was estimated to be about one million.

The author has examined many thousands of bats from a great variety of other roosts and environmental conditions. Examples: (1) 75 *M. v. incautus* in an attic at San Carlos, Gila Co., Arizona on July 31, 1948. In the attic the temperature was 99°F. and the relative humidity was 23 per cent. No ammonia odor was present. (2) Bryan P. Glass (personal communication) prepared 22 *M. v. incautus* taken in Alabaster Cavern, Woodward Co., Oklahoma on July 13, 1949. He states that the cave is very moist with a stream running through it and no ammonia odor is evident. (3) I examined 262 *T. b. mexicana* at a railroad bridge

roost near Malaga, Eddy Co., New Mexico on July 12, 1956. There was no ammonia present and the respective temperature and humidity readings were 95° and 17 per cent. (4) At Carlsbad Cavern, Eddy Co., New Mexico, 1028 *T. b. mexicana* were captured on August 28, 1956. August temperature and relative humidity readings in the bat cave section of the cavern range from 65–69° and 95–98 per cent. Here ammonia is rarely present, being detected in very weak concentration only one day during an entire summer's observations.

Analyses of specimens.—The specimens of *Tadarida*, *Myotis* and *Mormoops*, prepared as reported above, and 24 additional *Tadarida* from Ney Cave were supplemented by 356 skins from different areas and subjected to a study of age, color variation and molt (Constantine, 1957, 1958) using the color plates of Ridgway (1912) for color determinations. This study formed a basis for comparing atypical specimens from Frio Cave and Ney Cave. Resulting evidence indicated that *Tadarida* and *Myotis* undergo a single annual molt, males molting before the females, the molting period being in summer and fall. The new coat is comparatively dark, being Mummy Brown to Olive Brown in *Tadarida* and Avellaneous to Sepia in *Myotis*. As it ages, the new coat seems to fade or bleach to a lighter and more reddish color, being Bister or a color between Prout's Brown and Cinnamon Brown in *Tadarida* and Tawny-olive to a color between Tawny-olive and Sayal Brown in *Myotis*. Degrees of fading are obvious by spring. However, *Tadarida* and *Myotis* at Frio Cave and *Tadarida* at Ney Cave may fade or bleach earlier and by summer may be outstandingly light in color. Faded *Tadarida* from Frio Cave average lighter in color than "normal," usually being Cinnamon Brown; but individuals bridge the color gap between "normal" and the extremely bright Ney Cave specimens, which are Sayal Brown. Faded *Myotis* from Frio Cave vary dorsally from a color between Sayal Brown and Tawny-olive to Sayal Brown, the underparts being distinctly different from "normal" in each case. Immature bats from these caves were not unusual in color, and adults molted into "normal" fresh coats. Insufficient collections and lack of suitable comparative specimens of *Mormoops* prevented establishment of the relative color status of Frio Cave specimens, so the study of color in this species was not extensive enough to warrant consideration here.

Comparison of field data and specimens.—A comparison of field data and specimens showed a correlation between atypical pelage and the presence of high humidity and ammonia (Table 1). These data and the fact that atypical bats molted into "normal" coats seemed to rule out genetic factors and isolate the causative factor or factors to the immediate environment. A review of literature of both natural and experimental mammalian pigmentation provided no basis to consider the possibility of the unusual pigmentation being produced through a physiological medium, stimulated by an external or internal factor. As a necesary step in ruling out the physiological medium, and a preliminary measure to test the influence of water vapor and humidity, a *Tadarida* skin and a *Myotis* skin were suspended in the air space of a jar, the bottom of which contained a 25 per cent ammonium hydroxide solution. The specimens were exam-

TABLE 1.—*Correlation of atypically light-colored pelage with combinations of high humidity and ammonia*

ROOST	AMMONIA	R. H.	SPECIES	PELAGE COLOR
Carlsbad Cavern	None	High	*T. b. mexicana*	"Normal"
Malaga bridge	None	Low	*T. b. mexicana*	"Normal"
Alabaster Cavern	None	High	*M. v. incautus*	"Normal"
San Carlos attic	None	Low	*M. v. incautus*	"Normal"
L. E. Creek Cave	High	Low	*T. b. mexicana*	"Normal"
Frio Cave	High	High	*T. b. mexicana*	Atypical
			M. v. incautus	Atypical
Ney Cave	High	High	*T. b. mexicana*	Atypical

ined a week later, at which time the *Tadarida* had bleached to the color of Ney Cave *Tadarida* in the atypical coat and the *Myotis* had bleached to a color similar to the color of atypical Frio Cave *Myotis*. These observations stimulated a laboratory experiment to determine the effect of ammonia and water vapor on the hair color of live *T. b. mexicana* and to demonstrate that the bats could live through the experience.

Bleaching effect of water vapor and ammonia on hair color of live T. b. mexicana.—Three groups of three bats each were subjected to the conditions indicated in Table 2. All bats were collected at the same source at the same time. Before the experiment, the relatively fresh, unfaded pelage of these bats compared favorably with the pelages of freshly prepared skins from the same source.

A temperature of 86°F. and relative humidity of 62 per cent were maintained by heating and humidifying units within the room in which the experiment was conducted. Each bat of groups II and III was confined in a separate sealed glass container to which an oxygen-replacement source was provided. Excess carbon dioxide was removed by a KOH solution with indicator added. Relative humidity for groups II and III was maintained by the following concentrated salt solutions: NH_4Cl, 77 per cent; $(NH_4)_2SO_4$, 81 per cent; $NH_4H_2PO_4$, 92 per cent. Ammonia was provided for group III by an ammonium hydroxide solution within each glass container. By increasing the concentration of ammonium hydroxide, the concentration of ammonia was correspondingly increased. When not on test, the bats were kept in the same room and maintained according to a care program described elsewhere (Constantine, 1952). The experiment was conducted for 52 days and the bats subjected to experimental conditions for ten hours each day. Individuals of group III were exposed to increasing concentrations of ammonia as follows: 18 days, 0.0136 vol. per cent; 2, 0.0175; 5, 0.0214; 2, 0.0364; 2, 0.0436; 7, 0.0569; 11, 0.0758; 5, 0.1166. Concentration of ammonia was measured by bubbling known quantities of air through a known H_2SO_4 solution and titrating to a common pH.

A slight fading of the pelage of group III bats was detected on the forty-seventh day. On the fifty-second day all bats were killed and prepared as skins.

TABLE 2.—*Results of laboratory experiment to determine the effect of ammonia and water vapor on the hair color of live Tadarida b. mexicana*

SUBJECTS	TEMP., °F	R. H., %	AMMONIA	RESULTING COAT COLOR
Group I:				
Bat 1	86	62	Absent	Unchanged
Bat 2	86	62	Absent	Unchanged
Bat 3	86	62	Absent	Unchanged
Group II:				
Bat 1	86	77	Absent	Unchanged
Bat 2	86	81	Absent	Unchanged
Bat 3	86	92	Absent	Unchanged
Group III:				
Bat 1	86	77	Present	Bleached+
Bat 2	86	81	Present	Bleached+
Bat 3	86	92	Present	Bleached++

The coats of individuals of groups I and II were apparently unchanged. The pelage of bats 1 and 2 of group III had bleached within the color range of the atypical Frio Cave specimens. Bat 3 of group III had bleached within the color range of the lighter Ney Cave *Tadarida*.

DISCUSSION

The development of environmental conditions conducive to bleaching of pelage seems to be as follows: large numbers of metabolically active *Tadarida* cluster in cave rooms and the heat lost by the bats warms the rooms, as suggested by the drop in room temperature after the bats have left on the evening flight and the cooler temperature of these rooms at times when they are unoccupied for longer periods. Urine, guano and exhaled moisture undoubtedly contribute to the climate of cave rooms as does moisture which seeps through cave walls and ceilings. Guano probably has a stabilizing effect on the atmospheric humidity and other atmospheric elements. For example, its large mass, once moistened by any source, would have an effect on the atmospheric humidity, and this effect would not be expected to change for a considerable period of time. Warmth, dry or slightly damp guano, urine, and bats which occasionally fall from the clusters apparently influence the natality and mortality rates of the dermestids, for they abound under *Tadarida* clusters where favorable conditions prevail. Ammonia concentrations develop in proportion to the dermestid concentrations. Probably guano and urine contribute to ammonia production, but it is felt that dermestid activity is the primary source. When dermestids are not present in cave rooms, ammonia rarely occurs and then only in light concentrations. Moreover, dermestids maintained in tight containers and fed on dried flesh were found to produce astounding concentrations of the gas. Thus, *Tadarida*, in its selection and modification of certain cave roosts, seems to provide all the conditions

necessary to support the dermestids. In turn, the dermestids apparently produce ammonia which in combination with water vapor becomes ammonium hydroxide, which may bleach the pelages of the bats. *Myotis* and perhaps *Mormoops* at Frio Cave are apparently victims of circumstances for, although the guano floors of the rooms occupied by these bats are too wet to accommodate dermestids, the chain-fashion arrangement of the cave rooms forces the bats to endure an atmosphere of ammonia and even fly through the *Tadarida* rooms in order to leave the cave.

Bleaching of pelage by cave atmospheres should have been demonstrated by keeping foreign, captive bats in fresh pelage in the caves and providing the reciprocal arrangement with controls in each case. In addition, gas analyses should have been done at the caves during summer and fall, when ammonia was in great concentration. However, one cannot always foresee the prerequisites to the solution of an unsolved problem, and research time was limited. One may wonder why the fresh coats of young and adult Frio Cave and Ney Cave bats do not seem to bleach. Rate of bleaching may conceivably be affected by such secondary factors as outside atmospheric changes which result in increased air flow in and out of the caves, evacuating or diluting ammonia and modifying the humidity. Changing of cave roosts and migration, as determined in current studies by the author, by Villa R. (1956) and by Eads *et al.* (1957), may provide further complications. Dates of capture of atypically colored *Tadarida* would indicate that bleaching activity must be at its greatest in early summer when females and newborn young are restricted to the place where the young are born. Observations on *Tadarida* at Frio Cave suggest that by mid-July adults spend only enough time with the young to suckle them and may prefer to spend most of the daylight hours in parts of the cave containing less ammonia where young bats join them as soon as they can fly. This behavior pattern might explain the failure of bleaching in fresh coats of adult and young *Tadarida*, but the possible influence of human interference on this behavior must be considered.

Stager (1942) encountered atypically colored adult females which apparently do not differ in size from *T. b. mexicana*. Moreover, at that date one would expect adult females to be in old pelage and adult males and immature bats to be in dark, relatively fresh pelage. Certainly the Sayal Brown color of the Ney Cave females is unusual and could easily create the impression that the bat might deserve taxonomic distinction, particularly because they averaged larger than the darker *Tadarida* with which they were associated.

The foregoing problem may not be restricted to bats inhabiting certain Texas caves. Andersen's paper (1917) suggested that a similar problem existed in Asia. The author's investigations show that conditions conducive to bleaching exist in many Mexican caves. Although unexplained "color phases" exist in certain temperate bat species, they are particularly abundant in tropical forms. Interpretation will require (1) establishing a base line or determination of "normal" range of coat-color variation in each species, including "normal fading";

and (2) identification of "bleached" coats with the environmental factors conducive to bleaching.

SUMMARY

Discovery of atypically light-colored *Tadarida brasiliensis mexicana* and similar *Myotis velifer incautus* in certain Texas caves stimulated an investigation of the unusual pigmentation. Color variation and molt studies in bats from other areas provided a basis for a similar study and comparison of atypical specimens, demonstrating that the latter grow "normal" coats which apparently bleach to an unusual degree. The atypical pigmentation was correlated with presence of ammonia and high humidity in caves but not with ammonia alone. Live *Tadarida* were bleached to a similar degree when experimentally maintained in an atmosphere containing ammonia and high humidity.

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LITERATURE CITED

ANDERSEN, K. 1917. On the so-called colour phases of the rufous horseshoe-bat of India (*Rhinolophus rouxi* Temm.). Jour. Bombay Nat. Hist. Soc., 25: 260–273.

CONSTANTINE, D. G. 1952. A program for maintaining the freetail bat in captivity. Jour. Mamm., 33: 395–397.

———. 1957. Color variation and molt in *Tadarida brasiliensis* and *Myotis velifer*. Jour. Mamm., 38: 461–466.

———. 1958. Color variation and molt in *Mormoops megalophylla*. Jour. Mamm., 39: 344–347.

EADS, R. B., J. S. WISEMAN AND G. C. MENZIES. 1957. Observations concerning the Mexican free-tailed bat, *Tadarida mexicana*, in Texas. Texas Jour. Sci., 9: 227–242.

RIDGWAY, R. 1912. Color standards and color nomenclature. A. Hoen, Washington, D.C., iv + 44 pp.

STAGER, K. E. 1942. A new free-tailed bat from Texas. Bull. So. Calif. Acad. Sci., 41: 49–50.

STORER, T. I. AND P. W. GREGORY. 1934. Color aberrations in the pocket gopher and their probable genetic explanation. Jour. Mamm., 15: 300–312.

VILLA-R, B. 1956. *Tadarida brasiliensis mexicana* (Saussure), el murcielago guanero, es una subespecie migratoria. Acta Zoologica Mexicana., 1 (11): 1–11.

Communicable Disease Center, U. S. Public Health Service, Carlsbad, New Mexico. *Received March 5, 1957.*

DECEMBER FOOD HABITS OF MINK IN MISSOURI

By Leroy J. Korschgen

This study was conducted during the years 1951 to 1953, inclusive, with three principal objectives: (1) to learn the general winter feeding habits of mink in Missouri, as an aid to management; (2) to learn the extent of predation upon other managed species during the winter when foods are most difficult to obtain; and (3) to obtain information of value in appraising good mink habitat.

The mink, *Mustela vison*, ranks first in value among the furbearers of Missouri. An average annual take of about 16,775 pelts during the years 1950 to 1954, inclusive, brought more than a quarter of a million dollars each year to trappers and hunters. Prices for mink pelts have remained relatively stable at about $15.00 each, but annual take has declined in recent years (Sampson, 1956).

Materials for this study were collected with the cooperation of other Commission biologists, hunters, trappers, and fur buyers. Names of successful mink takers were obtained from fur harvest records. These and selected fur buyers were requested to save mink carcasses for study. Volunteer cooperators were supplied with one-gallon wide-mouthed jars or lard cans which contained a 10 per cent formaldehyde solution for preserving materials. Seventy-one of 89 cooperators who volunteered saved 362 carcasses for study during the 1951 (December) season. Sixty-three from essentially the same group saved 403 carcasses during December, 1952, while 36 of 50 cooperators saved 263 carcasses for study during December, 1953.

Collected materials were assembled each year and the stomachs removed for food habits study. Stomachs were opened, the contents washed in a fine-mesh sieve, and partially dried. Food items were separated by kind and identified, and the volume of each was ascertained.

Identification of food items was aided by use of a 10× binocular dissecting microscope. A compound microscope with 440× magnification also was used occasionally to check hair identifications. Other items used were standard laboratory equipment.

Percentages were calculated both for occurrence and volume of each identified food item, each year, and for the three-year total.

Reports from six other states show great variation in amounts of specific foods taken by mink. Dearborn (1932), reporting the winter diet of 297 Michigan mink, found that mammals, principally muskrats, occurred in 55.6 per cent of the samples. Fish, frogs, crayfish and birds were found frequently. Sealander (1943) also reported muskrat as the most important prey item of Michigan mink, as determined from the examination of 102 stomachs and 101 intestine samples. Hamilton (1936) found from the examination of 70 visceral samples that New York mink in winter fed principally upon mice, fish and crayfish, with muskrat fourth in importance. He later (1940) found from the examination of 300 scats that muskrat was most important in the summer diet of mink, while fish and aquatic beetles were next. These three items totaled 79.1 per cent of the bulk.

Errington (1954) reported the truly staple foods of mink in the north-central states as crayfish and frogs. He concluded, after examination of 13,176 mink scats, that mink preyed upon muskrats much more under conditions of drought or overpopulation. Stollberg and Hine (1952) also related predation by mink to muskrat density, after examination of 45 mink stomachs from Wisconsin. Guilday (1949), from analyses of 105 mink stomachs from southwestern Pennsylvania, concluded that mice, fish, crayfish and insects were the most important foods. Examination of 335 mink stomachs or intestines in North Carolina showed that fish, small mammals, arthropods, birds and frogs were the principal foods (Wilson, 1952).

Results and analyses.—The results of this investigation are shown in tabular form in Table 1. Foods are listed under major headings, in order of importance by volume.

Nearly two-thirds (63.8 per cent) of 1,028 stomachs examined were empty. The 372 which contained food served as a basis for this report and were collected as follows: 145 during 1951, 134 in 1952, and 93 during the 1953 season. There seems no ready explanation for the high proportion of empty stomachs, which was several times greater than that found for any other predatory species. Method of take possibly was a factor, since the majority of the animals were trapped.

Two methods of take were legal during the 1951 season—by traps, or by gun and dog. A comparison of stomachs collected by the two methods showed a great divergence in numbers which contained food. More than two-thirds (68.4 per cent) of the animals taken by dog contained food, as compared to 41.3 per cent of those taken by trap. Only trapping was legal during the 1952 and 1953 seasons, so no further comparisons could be made. The percentage of stomachs containing food dropped from 40.1 per cent for the combined take during 1951, to 33.3 and 35.4 per cent, respectively, for the trapped animals of 1952 and 1953.

Stomachs of female mink contained food more often than did stomachs of males. Percentages of the samples which contained food, for the three years, were as follows: 37.6 per cent males and 44.4 per cent of the females during 1951; 31.6 per cent males and 36.1 per cent of the females during 1952; and 30.2 per cent males and 43.6 per cent of the females during 1953.

Principal foods.—Data in Table 1 shows the principal foods of mink to be frogs, mice and rats, fish, rabbit, crayfish and birds, in order of importance by volume. Unlike the larger predators which consume their food in chunks or bolt smaller items whole, the mink thoroughly masticates what is eaten. Mastication adds to the difficulties of specific identification.

Frogs, the principal food group, were largely unclassified as to species. It is probable that the bulk of this category was made up of bullfrogs (*Rana catesbeiana*) and leopard frogs (*Rana pipiens*) which could not be positive identified without very laborious and time-consuming study. In only two instances were nearly whole frogs found. One of these was a medium-sized leopard frog; the other, five spring peepers (*Hyla crucifer*) in a single stomach.

Frogs as a group occurred in 25.5 per cent of the stomachs and comprised 24.9 per cent of the total volume of food. Both occurrence and volume of frogs varied little from 1951 to 1952, and utilization was nearly the same in the northern and southern parts of the state. Consumption of frogs during 1953 was only about one-half that of the preceding two years. Most small streams were dry during the fall and winter, except for intermittent pools, which limited opportunities for mink to find frogs.

Mice and rats were the second most important source of food and comprised nearly one-fourth (23.9 per cent) of the diet, by volume. Five species of mice and two of rats were identified in the stomach contents. White-footed mice (probably all *Peromyscus maniculatus* and *P. leucopus*) were the most important and made up 8.5 per cent, by volume. Meadow mouse (*Microtus ochrogaster*) comprised 5.9 per cent; cotton rat (*Sigmodon hispidus*), 4.5 per cent; house mouse (*Mus musculus*), 3.7 per cent; lemming mouse (*Synaptomys cooperi*), 0.6 per cent; harvest mouse (*Reithrodontomys* sp.), 0.4 per cent; unclassified mice, 0.2 per cent; and barn rat (*Rattus norvegicus*), 0.1 per cent of the mink diet. Only about one-half the amount of mice and rats were utilized in 1952, as compared to the 1951 take. A still smaller amount was found in the 1953 samples. These data corroborate evidence of a low mouse population during 1952 and 1953, except for localized areas. The lower utilization of mice and rats during 1952 appeared to have been compensated for largely by the greater utilization of fish. Greatest use of mice and rats occurred in the northern part of the state.

Fish were the third most important source of food. They were found in 30.9 per cent of the samples and comprised nearly one-fifth (19.9 per cent) of all food. The take of fish was least during 1951 when frogs and mice were taken in abundance. Consumption of fish more than doubled during the last two years of the study, accompanied by continuously lower water levels which probably increased the availability of fish. No attempt was made to identify the species of fish involved, except that the identification of bullhead catfish was obvious. Fish scales and bones normally were found, but with approximately 250 species known in Missouri, specific identification was considered impractical. A great variety of scale sizes and shapes was noted, indicating no preference for any particular kind of fish. Size of scales and bones showed that only small fish were taken regularly as food. Utilization of fish was general throughout the state.

Cottontail rabbit (*Sylvilagus floridanus*), the largest of the prey species found, occurred in 5.9 per cent of the samples and comprised 10.2 per cent of the total diet, by volume. The percentages of this item show that rabbit serves as at least a secondarily important mink food. Most of the occurrences of rabbit were in northern Missouri where this prey species was most abundant.

Crayfish (*Cambarus* sp.) were the fifth most important source of food. They were found in 19.9 per cent of the stomachs and comprised 9.3 per cent of the three-year December diet. Small amounts of crayfish commonly were found in stomachs with other foods, although often this food constituted the entire con-

TABLE 1.—*Foods of 372 mink in Missouri, by year, 1951–1953*

FOOD ITEM	Year:	PERCENTAGES BY OCCURRENCE AND VOLUME							
		1951		1952		1953		Total	
	No. stomachs:	145		134		93		372	
Frogs		(30.3)	(25.2)	(29.1)	(28.6)	(12.9)	(14.9)	(25.5)	(24.9)
Frogs, unclassified		29.0	22.7	29.1	28.6	12.9	14.9	25.0	23.6
Leopard frog, *Rana pipiens*		0.7	1.7	–	–	–	–	0.3	0.9
Spring peeper, *Hyla crucifer*		0.7	0.8	–	–	–	–	0.3	0.4
Mice and rats		(33.1)	(32.2)	(17.9)	(16.3)	(12.9)	(15 9)	(22.6)	(23.9)
White-footed mouse, *Peromyscus* spp.		14.5	12.7	6.7	6.0	4.3	1.1	9.1	8.5
Meadow mouse, *Microtus ochrogaster*		10.3	10.2	3.7	2.2	1.1	0.6	5.6	5.9
Cotton rat, *Sigmodon hispidus*		3.4	6.4	–	–	1.1	9.1	1.6	4.5
House mouse, *Mus musculus*		3.4	2.6	3.7	6.1	2.2	1.5	3.2	3.7
Lemming mouse, *Synaptomys cooperi*		0.7	0.1	0.7	0.4	1.1	3.0	0.8	0.6
Harvest mouse, *Reithrodontomys* sp.		–	–	1.5	1.2	–	–	0.5	0.4
Mouse, unclassified		–	–	1.5	0.4	3.2	0.6	1.3	0.2
Barn rat, *Rattus norvegicus*		0.7	0.1	–	–	–	–	0.3	0.1
Fish		(18.6)	(11.9)	(30.6)	(27.5)	(50.5)	(27.4)	(30.9)	(19.9)
Fish, unclassified		17.9	11.7	30.6	27.5	48.4	26.7	30.1	19.7
Bullhead catfish, *Ameiurus* sp.		0.7	0.2	–	–	2.2	0.7	0.8	0.2
Rabbit, *Sylvilagus floridanus*		6.9	13.3	6.0	5.0	4.3	12.4	5.9	10.2
Crayfish, *Cambarus* sp.		17.9	6.4	17.2	7.8	26.9	22.5	19.9	9.3
Birds		(6.2)	(5.1)	(9.0)	(8.5)	(1.1)	(tr.)	(5.9)	(5.6)
Songbirds (flicker, cardinal, bluebird, etc.)		2.1	1.6	7.5	8.1	1.1	tr.	3.8	3.7
Birds, unclassified		3.4	3.1	1.5	0.5	–	–	1.9	1.7
Quail, *Colinus virginianus*		0.7	0.3	–	–	–	–	0.3	0.2
Fox squirrel, *Sciurus niger*		1.4	2.8	0.7	0.4	2.2	4.8	1.3	2.2
Muskrat, *Ondatra zibethica*		1.4	1.0	0.7	1.9	1.1	1.1	1.1	1.3
Undetermined meat and blood		4.1	0.4	3.7	2.3	3.2	0.3	3.8	1.0
Invertebrates		(2.8)	(0.3)	(3.0)	(0.5)	(7.5)	(0.6)	(4.0)	(0.4)
Spiders		2.1	0.1	1.5	0.5	5.4	0.6	2.7	0.3
Tarantula		0.7	0.2	–	–	–	–	0.3	0.1
Ground beetle, cricket, scarab beetle, etc.		–	–	1.5	tr.	2.1	tr.	1.3	tr.
House cat, *Felis domestica*		–	–	0.7	0.8	–	–	0.3	0.3
Least shrew, *Cryptotis parva*		–	–	1.5	0.5	1.1	0.1	0.8	0.2

TABLE 1.—*Continued*

FOOD ITEM	Year:	PERCENTAGES BY OCCURRENCE AND VOLUME							
		1951		1952		1953		Total	
	No. stomachs:	145		134		93		372	
Snake, unclassified		0.7	0.2	–	–	–	–	0.3	0.1
Plant foods		(4.1)	(1.2)	–	–	(1.1)	(tr.)	(1.9)	(0.7)
Horsetail, *Equisetum* sp.		1.4	1.0	–	–	–	–	0.5	0.5
Grass		0.7	0.1	–	–	–	–	0.3	0.1
Plant stems and leaves		2.1	0.1	–	–	1.1	tr.	1.1	0.1
Total volume		1,429.2 cc.		1,059.0 cc.		439.5 cc.		2,927.7 cc.	
TOTAL		100.0%		100.0%		100.0%		100.0%	

tents. The occurrence of crayfish in the diet remained nearly constant during the first two years of this study, but showed greatly increased use during the third year. Drought conditions, mentioned previously, made this food more readily available in the nearly dry streams during 1953. Heaviest utilization of this item was in southern Missouri, where crayfish appeared in stomachs about three times as frequently as in stomachs from northern Missouri.

Birds as a group, but principally songbirds, were taken with sufficient frequency and volume to comprise a secondarily important source of food. Birds were found in 22 of the samples and comprised 5.6 per cent of the total bulk. Many items in this category could not be postivitely identified. Tentative identifications included three flickers, two juncos, a cardinal, bluebird, quail, and starling.

Fox squirrel (*Sciurus niger rufiventer*) was found occasionally, but could not be considered a staple food. Five occurrences of this item during the three years made up 2.2 per cent of the total volume of food.

Muskrat (*Ondatra zibethica*) occurred in four stomachs and made up 1.3 per cent of the December diet. This represents a very low percentage of the mink diet, as compared to the findings of investigators in other states. However, material for other reports often was collected from marsh areas where concentrations of mink and muskrats occurred together. Animals for this Missouri study came from a variety of habitats—streams, marshes, ponds and lakes. The small number of muskrats eaten could have represented trap-bound animals, since the trapping seasons for mink and muskrat were concurrent during the three years of this study.

Other items in the mink stomach contents occurred infrequently, or in such small amounts as to eliminate them from the list of important foods. Fourteen occurrences of animal matter and blood were found, the nature of which could not be distinguished. These foods were listed as undetermined, and collectively comprised 1.0 per cent of the total volume.

Invertebrates of six kinds, in addition to crayfish, were found in 15 samples. There were 10 spiders and one each of tarantula (*Eurypelma* sp.), ground beetle (Carabidae), cricket (Gryllidae), beetle larva (Coleoptera) and scarab beetle (Scarabaeidae). The collective volume of these items was insignificant at only 0.4 per cent of the total.

Other unimportant animal foods consisted of a young kitten (*Felis domestica*), three least shrews (*Cryptotis parva*) and an unclassified snake, which comprised only minor portions of the diet.

Plant items seldom were found. Seven occurrences of plant material included horsetail (*Equisetum* sp.), grass, and plant stems and leaves which probably were ingested incidentally or by trap-bound animals.

Effect upon wildlife.—These data reveal no seriously detrimental predation by mink upon other managed species of wildlife during December. Several species were utilized as food, but not in alarming proportions. Bullfrogs undoubtedly figured heavily in the frog portion of the diet, but the high potential of bullfrog reproduction, plus the limited number of mink in any area, make it doubtful that predation by mink seriously limits the bullfrog population. The same is true for fish, which are heavily utilized by mink; but fish, like frogs, have a high reproductive potential. This category, too, includes many rough fish and minnows not of particular interest to sportsmen. Rabbits, squirrels, muskrats and quail were not taken by mink with enough frequency to have affected the populations appreciably.

It appears evident that the small detrimental effect of mink predation upon other game species during December is amply compensated for by beneficial traits. The kill of rodents alone might be considered a balance to detrimental feeding. Fur value, as a cash crop to trappers, is an added benefit.

Habitat appraisal.—The information resulting from this study does not point clearly to a practical method of managing the mink food supply. A check of the important foods does, however, reveal a clue to the appraisal of good mink habitat. Frogs, mice, fish, rabbits, crayfish and birds were shown to be the principal foods. These foods normally are found most abundantly in and near water. Land areas adjacent to water and from which the vegetation has not been overgrazed, burned or cut, therefore, seem to provide excellent habitat for the terrestrial prey species. Water areas in such locations, too, usually are more productive of the aquatic foods—frogs, fish and crayfish.

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SUMMARY

A study of the food habits of mink in Missouri was conducted to learn: (a) the general winter feeding habits of mink in Missouri, to secure knowledge for management; (b) the

extent of predation upon other managed species of wildlife during winter when other foods are most difficult to obtain; and (c) information of value in appraising good mink habitat.

Mink stomachs from carcasses saved by cooperating hunters, trappers and fur buyers were used as study materials. Results include data from the examination of 372 mink stomachs from all parts of the state. In addition, 656 stomachs were empty.

Principal foods, by volume percentages, were: frogs, 24.9; mice and rats, 23.9; fish, 19.9; rabbit, 10.2; crayfish, 9.3; birds, 5.6; fox squirrel, 2.2; muskrat, 1.3; and undetermined meat and blood, 1.0 per cent.

The data indicate that mink predation is not seriously detrimental to other managed species of wildlife during winter.

Good mink habitat would seem to include land adjacent to water from which vegetation is not overgrazed, burned or cut. Such areas are productive of the foods most utilized by mink.

LITERATURE CITED

Dearborn, Ned. 1932. Foods of some predatory fur-bearing animals in Michigan. Univ. Mich. Sch. For. and Conserv., Bull. 1: 30–34.

Errington, P. L. 1954. The special responsiveness of minks to epizootics in muskrat populations. Ecol. Monogr., 24: 377–393.

Guilday, J. E. 1949. Winter food of Pennsylvania mink. Penn. Game News, 20(9): 12, 32.

Hamilton, W. J., Jr. 1936. Food habits of the mink in New York. Jour. Mamm., 17: 169.

———. 1940. The summer foods of minks and raccoons on the Montezuma Marsh, New York. Jour. Wildl. Mgt., 4: 80–84.

Sampson, F. W. 1956. Population trends of furbearers—mink. Unpubl. P-R Report, Missouri 13-R. 12 pp.

Sealander, J. A. 1943. Winter food habits of mink in southern Michigan. Jour. Wildl. Mgt., 7: 411–417.

Stollberg, B. P. and R. L. Hine. 1952. Food habits studies of ruffed grouse, pheasant, quail and mink in Wisconsin. Wisc. Conserv. Dept. Tech. Wildl. Bull., 4: 1–22.

Wilson, K. A. 1952. The role of mink and otter as muskrat predators in northeastern North Carolina. Jour. Wildl. Mgt., 18: 199–207.

Conservation Commission, Columbia, Missouri. Received May 27, 1957.

FOOD HABITS OF THE SWIFT FOX IN NORTHERN TEXAS

By William L. Cutter

Swift foxes, *Vulpes velox velox*, are present in many parts of their range where they were once considered to be extinct. Little has been learned about the natural history of swift foxes, probably owing to the scarcity of the species until recent years. Twelve stomachs and 250 scats were obtained at six localities in Hansford County, Texas, and were studied to determine the feeding habits of swift foxes.

Most of the land in Hansford County is farmed or overgrazed. Swift foxes and their dens have been found in both cultivated and uncultivated fields (Cutter, 1958). Growers of livestock and poultry are not now (1956) troubled by predators, but perhaps formerly were since government trappers have set

"coyote getters" in the past—mechanisms that explode a small bomb in the mouths of investigating coyotes.

Two of the 12 stomachs were empty; the 250 scats were gathered near the entrances to dens. The scats and stomachs were collected in late spring, summer and early autumn, with the exception of one stomach and five scats, obtained in winter. Young are in the dens in spring and summer; the scats may be mainly from young animals. Contents of stomachs and scats are discussed separately in the pages that follow. The number of individuals of each species eaten by the swift foxes could not be determined.

MAMMALS

Rabbits.—Remains of rabbits were found in 55 scats and five stomachs. Remains from two scats and from two stomachs were identified as black-tailed jack rabbit, *Lepus californicus,* and remains from nine scats and from three stomachs were identified as cottontail rabbit, *Sylvilagus* sp. (probably *S. audubonii*). Rabbits occurred almost as frequently (60 times) as did all other vertebrates (68 times). Many of the rabbit remains were of immature animals; probably most rabbits eaten by swift foxes are young animals.

Many swift foxes were found dead on highways in Hansford County, where they had been struck by passing vehicles, probably because the foxes were feeding on animals killed by motor vehicles. Swift foxes readily accept any meat used as trap bait. I once observed a dead swift fox on the highway, with rabbit fur tightly locked in its jaws, only inches from a mangled rabbit that seemed to have been dead longer than the fox.

Citellus tridecemlineatus.—Remains of thirteen-lined ground squirrels were found in only two stomachs. This ground squirrel is relatively common in the county and may not be preyed upon more often because the ground squirrel is diurnal, whereas the fox is nocturnal in its foraging.

Perognathus (probably *flavus*).—Remains of small pocket mice were in four scats. These mice are common in the area. Blair (1954: 247) states that *Perognathus merriami* is more common in the northern Panhandle of Texas than *Perognathus flavus.* Possibly the two kinds are merely subspecies.

Perognathus hispidus.—Teeth and jaws of the hispid pocket mouse were in four scats. These mice are common, especially in cattle paths along fence rows. Swift foxes forage a great deal along these paths.

Dipodomys ordii.—Remains of kangaroo rats appeared in only three scats. This infrequency of occurrence may be attributed to the absence of large colonies of kangaroo rats within the foraging range of the swift foxes. Many workers are of the opinion that the closely related kit fox, *Vulpes macrotis,* of the region west of the range of the swift fox, preys heavily on kangaroo rats. Bailey (1932: 300) suggests that the range of *Vulpes macrotis neomexicanus* coincides with the range of the banner-tailed kangaroo rat, *Dipodomys spectabilis,* in New Mexico. Grinnell *et al.* (1937: 417) state that the areas occupied by *Vulpes macrotis* and *Dipodomys deserti* in California coincide. Davis and Robertson

TABLE 1.—*Numbers of scats and stomachs containing items used as food by swift foxes in Hansford County, Texas. The contents of 250 scats and 10 stomachs were examined*

SPECIES	NO. OF SCATS	PER CENT OF SCATS	NO. OF STOMACHS
Mammals:			
Unidentified rabbit	44	17.6	
Sylvilagus audubonii?	9	3.6	3
Reithrodontomys megalotis	8	3.2	
Perognathus hispidus	4	1.6	
Perognathus flavus?	4	1.6	
Dipodomys ordii	3	1.2	
Citellus tridecemlineatus	–	—	2
Lepus californicus	2	0.8	2
Onychomys leucogaster	2	0.8	
Peromyscus maniculatus	1	0.4	
Reithrodontomys montanus	1	0.4	
Peromyscus sp.	1	0.4	
Birds:			
Passerine birds	24	9.6	1
Eremophila alpestris	4	1.6	
Spizella pusilla	–	—	3
Junco hyemalis	–	—	1
Reptiles:			
Sceloporus undulatus	1	0.4	
Phrynosoma cornutum	1	0.4	
Cnemidophorus sexlineatus	1	0.4	
Unidentified lizard	–	—	1
Fishes:			
Unidentified fish	3	1.2	
Invertebrates:			
Locustidae	22	8.8	7
Tenebrionidae	11	4.4	3
Scarabaeidae	10	4.0	5
Gryllidae	10	4.0	4
Carabidae	8	3.2	4
Stenopelmatidae	8	3.2	4
Formicidae	5	2.0	
Tettigoniidae	2	0.8	2
Chrysomelidae	2	0.8	
Cicadidae	1	0.4	
Specidae	–	—	1
Solpugida	3	1.2	
Araneida	2	0.8	
Vegetable material:			
Gramineae	43	17.6	10

(1944: 264) and Taylor and Vorhies (1923: 255) report kangaroo rats stolen from snap traps by *Vulpes macrotis*.

Reithrodontomys montanus.—Remains of the plains harvest mouse were found in one scat. This mouse is scarce in the county, and Blair (1954: 249) mentions the scarcity of the species in the Panhandle.

Reithrodontomys megalotis.—Remains of western harvest mice were found in eight scats. The species is more common than *R. montanus* and occurs even in overgrazed pastures with little cover.

Peromyscus maniculatus.—Only one scat contained the remains of the deer mouse. Remains of an unidentified *Peromyscus* were in another scat. Both deer mice and white-footed mice, *Peromyscus leucopus,* are common near the fox dens.

Onychomys leucogaster.—Remains of the northern grasshopper mouse were identified from two scats. This is probably the most abundant rodent in the area, as indicated by trapping, and it is surprising that it was not more often used as food.

BIRDS

The remains of birds were found in 28 scats and five stomachs. Unidentifiable passerine remains were found in 24 scats. Horned larks, *Eremophila alpestris,* were found in four scats. The remains of two other species, a lark bunting, *Calamospiza melanocorys,* and a cowbird, *Molothrus ater,* were at the entrance to a den. One stomach yielded a bird identified as a passerine and another stomach contained a slate-colored junco, *Junco hyemalis.* Three nestling field sparrows, *Spizella pusilla,* were found in two stomachs.

The identified species were all flock birds or ground nesters and therefore could be preyed upon by swift foxes. It is noteworthy that no gallinaceous birds, either game birds or domestic poultry, were found. Two of the dens where scats were gathered were no more than 200 yards from a farmyard where poultry was raised.

REPTILES

Four lizards were found in three scats and one stomach. Three of these were identified as the eastern fence lizard, *Sceloporus undulatus,* the Texas horned toad, *Phrynosoma cornutum,* and the six-lined racerunner, *Cnemidophorus sexlineatus.* No remains of snakes were found, although White (*in* Grinnell *et al.,* 1937: 416) found remains of a snake near a den of *Vulpes macrotis* in California.

FISH

Unidentified fish were found in three scats. The people of the area frequently stock playas and stocktanks with fish, but these bodies of water disappear in dry years. At such places I have noted, in the mud, tracks of swift foxes and other predators that probably had fed on stranded fish and amphibians.

INVERTEBRATES

Insects of 11 families were found in scats and stomachs. Short-horned grasshoppers (Locustidae) occurred most frequently. Dr. George W. Byers, who

identified the Arthropoda, informed me that most of the grasshoppers were of the subfamily Oedipodinae, that the most common species of camel cricket (Stenopelmatidae) was *Udeopsylla robusta*, and that most of the crickets (Gryllidae) were *Achaeta*. Some of the other common families were the Scarabaeidae, Tenebrionidae and Carabidae.

Insect remains comprised approximately 29 per cent of the bulk of the stomach contents and 55 per cent of the bulk of scats. These are impressive figures, especially when one considers the damage that certain insects can do to cultivated crops and grass.

Three sun spiders (Solpugida) and two spiders (Araneida) were in five scats.

VEGETABLE MATERIAL

Grass was in 43 scats and 10 stomachs. The only grasses identified were buffalo grass, *Buchloe dactyloides*; brome grass, *Bromus* sp.; and milo maize, *Sorghum vulgare*. There was usually only a trace; however, two scats were composed entirely of finely masticated grass.

Other canids are known to use some plant material as food, and swift foxes are probably no exception. Maximilian (*in* Baird, 1857: 136) wrote of the stomach contents of swifts, "commonly full of fragments of skin, leather with hair, berries, remnants of mice, and grasshoppers." Hawbecker (1943: 499) reported that brome grass was found in all of 74 scats examined of the kit fox, *Vulpes macrotis mutica*. It seems likely, however, that at least part of the vegetable material found in the specimens from the Panhandle may have been ingested accidentally. For example, undigested bird crops containing grass and milo maize were found in the stomachs of two swifts.

MISCELLANEOUS NONFOOD ITEMS

A metal brad was in one scat and small pebbles were in many of the scats and stomachs. The stomachs of two swift foxes that were trapped contained chewed pieces of canvas which had been used as trap covers.

Parasitic worms were in all stomachs examined. These worms were identified by Clarence E. Harms as *Physaloptera* sp. and *Dipylidium caninum*.

DISCUSSION

No one has studied the food habits of the swift fox in detail; nevertheless, various items that both swift foxes and kit foxes eat have been mentioned in the literature. Seton (1929: 556) wrote that the northern swift fox, *Vulpes velox hebes*, had been known to hunt prairie chickens in Alberta and mentioned one instance of chicken thievery. Bailey (1927: 165) recorded northern swift foxes as camp scavengers in North Dakota. Grinnell *et al.* (1937: 412) reported an instance of chicken thievery by *Vulpes macrotis* in California but concluded that the kit fox of California had few habits injurious to man or his possessions and possessed positive values that far more than counterbalanced its faults. Egoscue (1956: 355) recorded the foods of *Vulpes macrotis* in Utah.

It is unfortunate that more material was not available for the study, from all seasons of the year. The diet probably varies seasonally with the availability of food. There is also a question of whether the diet of adults differs from the diet of whelps. It may be that foraging adults bring only larger species, such as rabbits, to small whelps at the den. The whelps, at most of the dens where scats were gathered, were large enough to forage for themselves, and I have observed small whelps near their den catching grasshoppers.

LITERATURE CITED

Bailey, V. 1927. A biological survey of North Dakota. N. Amer. Fauna 49, vii + 226 pp.

———. 1932. Mammals of New Mexico. N. Amer. Fauna 53, 1–412 pp.

Baird, S. F. 1858. Reports of explorations and surveys . . . for a railroad from the Mississippi River to the Pacific Ocean. Vol. 8 (Part 1, Mammals): xxxii + 757 pp.

Blair, W. F. 1954. Mammals of the Mesquite Plains Biotic District, and speciation in the central grasslands. Texas Jour. Sci., 6: 235–264.

Cutter, W. L. 1958. Denning of the swift fox in northern Texas. Jour. Mamm., 39: 70–74.

Davis, W. B. and J. L. Robertson, Jr. 1944. The mammals of Culberson County, Texas. Jour. Mamm., 25: 254–273.

Egoscue, H. J. 1956. Preliminary studies of the kit fox in Utah. Jour. Mamm., 37: 351–357.

Grinnell, J., J. S. Dixon and J. M. Linsdale. 1937. Fur-bearing mammals of California. Univ. Calif. Press, Berkeley, Vol. 2: pp. 377–777.

Hawbecker, A. C. 1943. Food of the San Joaquin kit fox. Jour. Mamm., 24: 499.

Seton, E. T. 1929. Lives of game animals. Doubleday, Doran and Co., New York, 2: 340–640.

Taylor, W. P. and C. T. Vorhies. 1923. Kangaroo rats and scorpion mice on the Santa Rita Reserve, Arizona. Jour. Mamm., 4: 255.

Museum of Natural History, Univ. of Kansas, Lawrence. Received May 20, 1957.

MELANISTIC GRAY SQUIRRELS IN CAMERON COUNTY, PENNSYLVANIA

By William A. Creed and Ward M. Sharp

Several studies of the gray squirrel have been made in the eastern states, but relatively little attention has been given to wild populations of the northern gray squirrel, *Sciurus carolinensis leucotis*, where the melanistic color phase was common. Perhaps nowhere within the gray squirrel's present range is the black squirrel more prevalent than in certain regions of Pennsylvania. It was for this reason that our squirrel studies in the Ridge and Valley Province of the state, where the melanistic phase was not encountered, were expanded to include a study of a gray-black squirrel population in Cameron County, Pennsylvania.

Forests in Cameron County are typical high country types—beech-birch-maple and transition hardwoods—and it is within these types that the black squirrel finds its optimum habitat. When observed in the field under most light conditions, these squirrels appear black. But upon live-trapping and handling melanistic gray squirrels, it was apparent that the intensity of blackness varied among individuals. Pure black squirrels were objects of rare beauty when encountered in full winter pelage. The purpose of this paper is to report not only on the color phases of the melanistic gray squirrel, but to discuss something of its history in Cameron County, the ratio of blacks to grays in a wild population, the sex ratio, general range and ecology.

Historical accounts.—The most comprehensive report of the decline of black squirrels in regions where they were once abundant is the historical account by Schorger (1949) according to which the black squirrel was formerly present in New York, Vermont, New Hampshire, Pennsylvania, Ohio, Indiana, Illinois, Michigan and Wisconsin. It is now restricted to reduced portions of the northernmost limits of its former range. From the mid-Appalachian Plateau and High Mountain provinces in West Virginia and Pennsylvania the present range of the melanistic gray squirrel extends north to Canada and west across the Lake States through Wisconsin. It is common in certain ecological niches, but in general its occurrence is erratic.

Rhoads (1903) traced the presence and relative numerical status of the melanistic phase in Pennsylvania in the late 1800's. His basis for determining the proportion of gray and black phases was answers to questionnaires sent to residents of the various counties. Reports by two residents of Cameron County indicated that the black and gray color phases were approximately equally divided in 1896 and 1899.

In March, 1920, an article appeared in the Altoona, Pennsylvania, Times-Herald (Seton, 1937) reporting a great squirrel migration in 1859 in McKean County which is adjacent to our study area. According to this report, practically all of the squirrels were of the black phase. C. W. Dickinson, source of the information, allegedly stated that grays had increased by 1920 and the ratio was approximately two grays to three blacks.

Rhoads (*op. cit.*), upon analyzing his data, concluded that "there seems to be a diminution of the relative number of blacks as the country becomes deforested and settled upon."

The color ratio found during this study seems to indicate a further reduction of the melanistic phase since 1920. This may not be entirely true, since historical records were apparently based on casual observation, with no precise sampling method.

Color phase and sex ratios.—The black to gray color ratio of 250 squirrels live-trapped and ear-tagged during 1955 and 1956 was 1:1.63. A limited hunters' bag-check of 87 squirrels in 1955 revealed a 1.26:1 ratio. In 1956, a sample of 210 taken from hunters' bags presented a 1.19:1 ratio. Thus, there is some disparity between the ratio shown by live-trapping and that indicated by kill.

This preponderance of the melanistic phase found in the hunters' bag-check may be the result of (1) a tendency of hunters to "select" blacks over grays when they are available, or (2) the possibility that black squirrels are more easily discerned against the natural forest background, and hence more easily bagged. This second hypothesis may be worth consideration; for a short period in the fall of 1955, the senior author kept a day-to-day record of blacks and grays observed. Of 29 squirrels recorded, 22 were melanistic.

A sample of 143 melanistic squirrels examined and sexed during the investigation showed a sex ratio of 93 males to 100 females.

Color variations of melanistic squirrels.—Examination of the melanistic squirrels handled during the study indicated a wide range of melanistic saturation, but most of the individual squirrels could be placed in three distinct color groups:

Group I: The most common color marking shown by these black squirrels was of the following nature: Dorsal surface with black hairs, of which many showed a 1 mm. buff band approximately 2 mm. back from the tip, giving the animal a brownish-black appearance. This buff banding was usually more intense on the sides of the individual, diminishing toward the dorsal midline. Tails were often correspondingly flecked with buff, though the buff band was considerably wider. Belly hairs of these individuals were predominantly rusty-brown.

The intensity of the buff banding of hairs on the sides and dorsum of squirrels in this group varied immensely; the widest range of melanistic saturation occurred within Group I. Of the squirrels examined, 112 possessed color characters placing them in this group (Plate 1).

Group II: The second most common color pattern included only 15 individuals. These squirrels were jet black, both dorsally and ventrally, except for a few scattered silvery-white hairs on the dorsal surface and tail.

Group III: Twelve squirrels were totally jet black. This color phase was the least common that could be classified as a definite color group (Plate I).

In addition to the above color patterns, four squirrels were captured that exhibited individual color anomalies. Squirrel No. 53 possessed a completely black dorsal surface, yet the ventral surface was rusty-brown. Squirrel No. 200 had a black dorsal surface with scattered silvery hairs, and rusty-brown belly fur with a white patch about the size of a quarter on the sternum. Squirrel No. 124 had rusty-brown belly hairs, and a dorsal surface so heavily flecked with gray as to give the animal a "smoky" appearance.

By far the most unusual color marking of any of the individuals handled was shown by squirrel No. 176. This extraordinary specimen exhibited both melanism and erythrism. Many of the black hairs on the dorsum of the animal were tipped with red, giving the fur a reddish-black appearance. The tail was completely red, the red coloration quite similar to the tail of the red squirrel, *Tamiasciurus hudsonicus loquax*. This unusual squirrel also had the rusty-brown belly which seems so typical of the melanistic squirrels found in this region.

The question is sometimes asked if the summer and winter molts change the color pattern of the melanistic squirrels. We have no information other than that color patterns are inherent and they remain relatively constant among individuals.

Genetics.—A survey of literature regarding melanism in the gray squirrel presented little information regarding the nature of its heritance. Shorton (1945), upon finding a litter containing three grays and one black, with both parents supposedly of the gray phase, assumed that melanism in this species was recessive and unifactorial.

C. E. Germain (1956, *in litt.*) reported a litter of one gray, one black and one

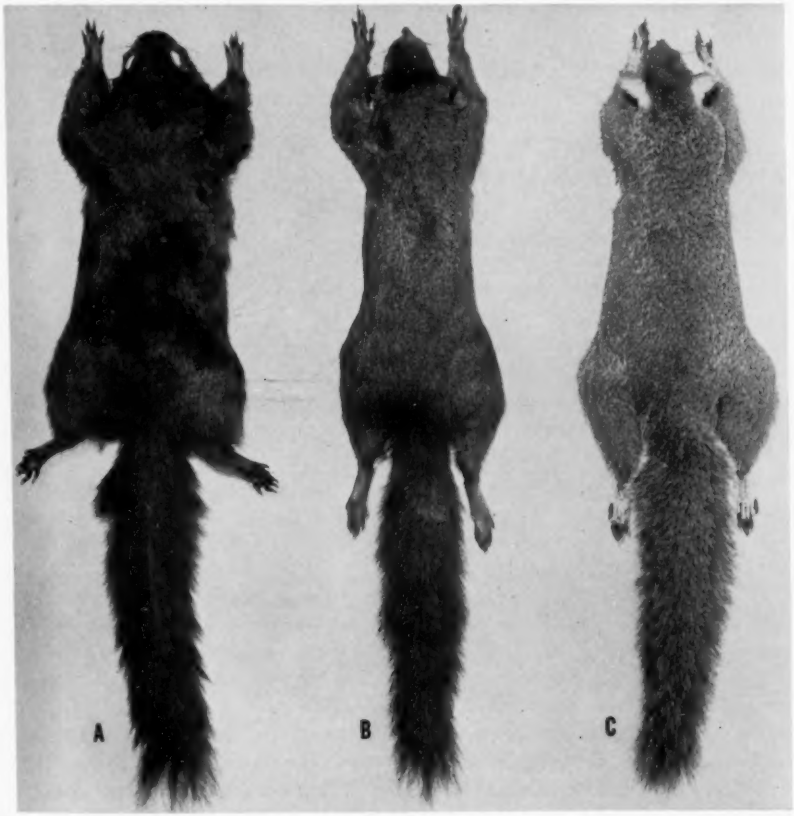

PLATE I

Three color variations of gray squirrels: *A*, squirrel with jet black pelage (Group III); *B*, squirrel with lesser saturation of melanism (Group I); *C*, normal gray phase. (*Picture by Photographic Service, Pennsylvania State University; study skins by Ward M. Sharp.*)

albino, which were reared in a bird house near his home in Wisconsin in 1953. One of the parents of this litter was gray, the other melanistic.

Color patterns of black squirrels described in this report indicate the probable presence of genes affecting the distribution of black pigment. In addition, segregation of other genes might account for the presence or absence of other pigments, such as red.

According to the Hardy-Weinberg Law (Stern, 1943) of population equilibrium, the ratio of blacks to grays should remain stable providing there is random mating and non-selective mortality. Selective shooting of blacks would, of course, be an important factor leading to a reduced ratio.

Discussion.—Once found over much of the northern hardwood and transition forest types, the black squirrel is now restricted to remnant northern hardwood wilderness areas. Selective shooting, no doubt, contributed to its present scarcity, but on the basis of the genetic pattern stated above, heterozygous individuals among the existing gray strain could continue to perpetuate the recessive melanistic color phase. Optimum habitat and climatic conditions must provide part of the answer. Regarding this we are not, at present, sufficiently informed to offer an explanation. But the range of the "gray" population of beech (*Fagus grandifolia*) and the melanistic gray squirrel do have something in common.

The black phase of the northern gray squirrel occurs in nature at high altitudes or in the more northern parts of the species' range. Its distribution coincides with the uppermost tolerance limits of the range of the gray squirrel—the Transition and Canadian life zones. Here melanism provides a contrast to northern mammals that become white in winter. An explanation postulated by Green (1936) was that this geographical difference in color change (white pelage in winter) has a genetic basis. It apparently also applies to the black phase of the gray squirrel. Melanism in gray squirrels tends to substantiate Svihla's (1956) findings that heat conservation at low temperatures does not differ between white and dark-colored rats. The dark pelage of the melanistic gray squirrel apparently is just as efficient in the conservation of heat as the white coats of the weasel or snowshoe hare that occupy the same forest community with the black squirrel.

The black squirrel is known to the authors to occur as far south as Pocohontas County, West Virginia. Here the junior author was familiar with a population prior to World War I. Many of these melanistic squirrels were heavily flecked with gray, imparting a smoky appearance. Their haunts were above an altitude of 3500 feet in the beech-maple and transition hardwoods. This area was ecologically similar to the forest types in Cameron County, Pennsylvania. This high country, like that in Pennsylvania, parallels the Ridge and Valley Province. Yet it was rare that black squirrels moved to the Valley region in appreciable numbers. The same nature of movement prevails today in Pennsylvania where black squirrels appear only rarely in the Ridge and Valley Province.

Introductions of the melanistic phase have been made in city parks and in Great Britain. Hibbard (1956) reported the black phase of the gray squirrel

occurring in McHenry and Ramsey counties of north-central and northeastern North Dakota. These perhaps have resulted from introductions of melanistic genetic strains.

SUMMARY

Though now found on only a remnant of its former range, the black squirrel is still abundant on the Allegheny Plateau in Pennsylvania. A gray-black squirrel population was studied in Cameron County, Pennsylvania, from August, 1955, to February, 1957. Color ratios of squirrels live-trapped and killed by hunters indicated a reduced black:gray ratio since 1920. Selective shooting is presented as a possible factor contributing to the decline of the melanistic phase.

The sex ratio of 143 melanistic squirrels was 93 males to 100 females. Three color variations of melanistic squirrels are described. The presence of genes affecting distribution of black pigment is a probable cause of the wide range of melanistic saturation found in individual squirrels.

Acknowledgments.—The writers wish to express their special thanks to Dr. J. E. Wright, The Pennsylvania State University, for constructive comments on genetics used in the manuscript. This is paper No. 88 of the Pennsylvania Cooperative Wildlife Research Unit, and Journal Series No. 2162 of the Agricultural Experiment Station, The Pennsylvania State University.

LITERATURE CITED

Green, C. V. 1936. Observations on the New York weasel, with remarks on its winter dichromatism. Jour. Mamm., 17: 247–249.

Hibbard, Edmund A. 1956. Range and spread of the gray and fox squirrels in North Dakota. Jour. Mamm., 37: 525–531.

Rhoads, Samuel N. 1903. The mammals of Pennsylvania and New Jersey. Privately published, Philadelphia, pp. 52–56.

Schorger, A. W. 1949. Squirrels in early Wisconsin. Trans. Wisc. Acad. Sci., Arts and Lett., 39: 195–247.

Seton, Ernest Thompson. 1937. Lives of game animals. The Literary Guild of America, N. Y. Vol. 4, p. 17.

Shorton, Monica. 1945. Inheritance of melanism in grey squirrels. Nature, 156: 46.

Stern, Curt. 1943. The Hardy-Weinberg Law. Science, 97: 137–138.

Svihla, Arthur. 1956. The relation of coloration in mammals to low temperature. Jour. Mamm., 37: 378–381.

Pennsylvania Cooperative Wildlife Research Unit and School of Forestry, The Pennsylvania State Univ., University Park. Received July 10, 1957.

THE BOG LEMMING FROM THE PLEISTOCENE OF FLORIDA

By Stanley J. Olsen

Although the southern bog lemming is not indigenous to Florida at the present time, remains of an extinct species belonging to the genus *Synaptomys* have been known for over two decades. Simpson (1928) established the new species *australis*, using a lower jaw which was collected from the Pleistocene deposit of

Saber-tooth Cave, as a basis for his type description. Additional material of this same species turned up in excavations of the Pleistocene beds of Seminole Field (Simpson, 1929; Cooke and Mossom, 1928). Pierce Brodkorb, of the University of Florida, was responsible for bringing to the attention of the writer numerous specimens of this heretofore rare form. These specimens were collected from the rich cave deposits near Reddick, Florida, and an isolated lower jaw was also collected from a newly reported sinkhole near Arrendondo, Florida—this last in association with a typical Florida Pleistocene fauna.

The southernmost range of this boreal rodent is now many miles to the north of Florida (Fig. 1). Its range during the Pleistocene was not confined to peninsular Florida, as additional specimens have been collected and recorded from a quarry in southwestern Kansas (Hibbard, 1954, 1955). This last named site is located within an area from which Recent species have also been recorded (Fig. 1).

Enough new material of *Synaptomys australis* is now known to justify recording this additional information and figuring for the first time the upper dentition, including the diagnostic superior incisor (Fig. 2).

The classification of rodents is subject to controversy among the various specialists working with these forms. The taxonomy here used is accepted by G. G. Simpson (1945) and A. E. Wood (1955):

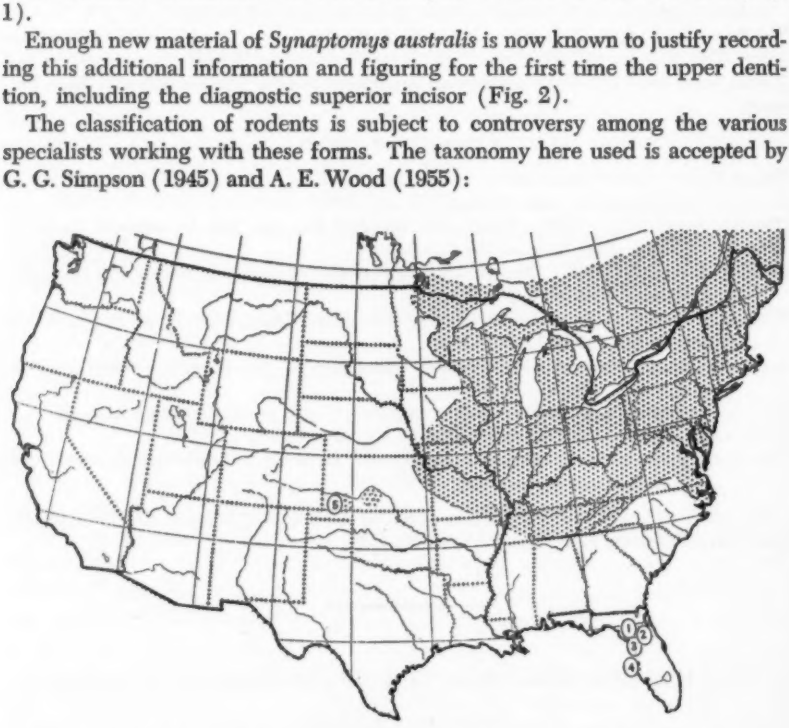

FIG. 1.—Stippled area indicates approximate distribution of southern bog lemming, *Synaptomys cooperi*; adapted from A. B. Howell (1927) and W. H. Burt (1952). Numbers indicate Pleistocene localities from which the remains of *Synaptomys australis* have been collected; (1) Arredondo Sink, (2) Reddick Cave, (3) Saber-tooth Cave (type locality), (4) Seminole Field, (5) XI Ranch (Jinglebob locality).

Family CRICETIDAE Rochebrune 1883
Subfamily MICROTINAE Miller 1896
Genus *Synaptomys* Baird 1857

Generic characters (Fig. 2): Grooved upper incisors, rootless molars with persistent pulp never projecting far above the alveoli, mandibular incisor with root on lingual side of molars and terminating at a point slightly posterior to M_3. The re-entrant angles are excessively deep on the buccal side of the maxillary molars, and on the lingual side of the mandibular ones.

Synaptomys australis Simpson 1928

Type: American Museum of Natural History, No. 23440. Right lower jaw with cheek teeth.

Horizon and locality: Saber-tooth Cave, Citrus County, Florida (Fig. 1). Pleistocene.

Specific characters: Pattern of lower cheek teeth as in *S. cooperi*, but enamel relatively thinner and size much larger (about 35 per cent). Total length of lower molars on surface of wear, 8.4 mm.

Referred material: Arredondo (Fig. 1), Florida Geological Survey No. V-5704. Left lower jaw with complete dentition. Sinkhole in quarry at Arredondo, Alachua County, Florida. Pleistocene. *Reddick* (Figs. 1, 2), Florida Geological Survey Nos. V-5699, right M^1, M^2; V-5700, right lower jaw, complete dentition;

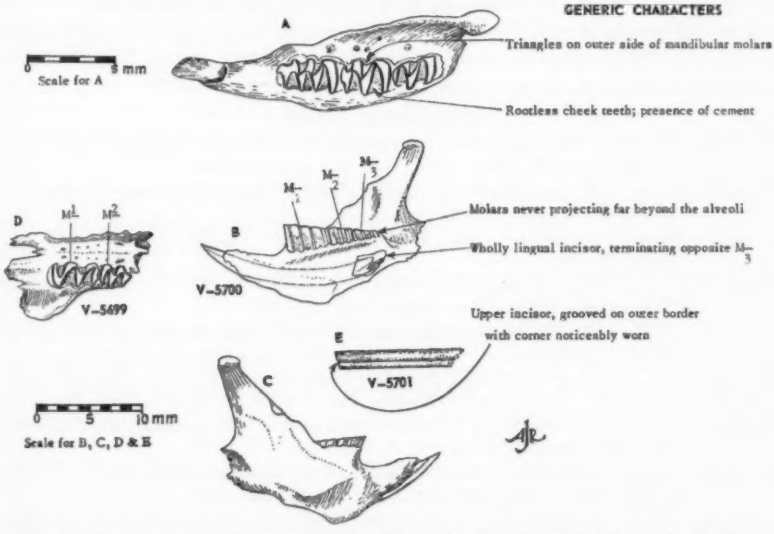

FIG. 2.—Dentition of *Synaptomys australis*; *A*, occlusal, *B*, lingual and *C*, labial views of right lower jaw dentition, F. G. S. No. V-5700; *D*, occlusal view of partial right upper dentition, F.G.S. No. V-5699; *E*, left upper incisor, F.G.S. No. V-5701.

V-5701, upper left incisor; V-5702, V-5703, lower left jaws with complete dentitions. From pit of Dixie Lime Products Company, one mile southeast of Reddick, Marion County, Florida. Illinoian stage of the Pleistocene.

Discussion.—*Synaptomys* is usually included in a boreal fauna and its presence in Florida during Pleistocene times may be explained by a temperature change brought on by the advancing glaciers. Whether or not the cooling effect of the glaciers would bring about a temperature change in Florida, similar to that found in Virginia and Tennessee today, cannot be definitely proved. But certainly this seems to be a logical explanation for the absence of this rodent in Florida today, particularly since no geographical barrier is apparent between the Pleistocene and present-day ranges.

Brodkorb (1957) has determined from the avifauna of the Reddick locality that this area during Pleistocene times was that of a freshwater marsh or wet grassland and that the accumulation of rodent skull fragments and jaws was due to pellets cast by owls using the cave for a roost.

A parallel case of rodent "migration" to northern climes is to be found in the muskrat *Ondatra zibethica* found in Pleistocene deposits of Florida, but living at present many miles to the north (Lawrence, 1942).

Whether the minute differences between S. *cooperi* and S. *australis* (being mainly of size) are enough to warrant specific designation, as opposed to a classification of subspecies or race, seems to be a matter of taste since very little of the postcranial skeleton has been identified and nothing of the external characters of this animal will be known for a comparison of the two forms.

The difference of an additional small groove on the inner side of the upper incisor (V-5701) may or may not be characteristic of S. *australis*. This particular tooth is known from one specimen at the present time.

LITERATURE CITED

Brodkorb, P. 1957. New passerine birds from the Pleistocene of Reddick, Florida. Jour. Paleont., 31: 129–138.

Burt, W. H. and R. P. Grossenheider. 1952. A field guide to the mammals. Houghton Mifflin Co., Boston, 200 pp.

Cooke, C. W. and S. Mossom. 1928. Geology of Florida. Florida Geol. Surv. 20th Ann. Rept.: 31–227.

Hibbard, C. W. 1954. A new *Synaptomys*, an addition to the Borchers interglacial (Yarmouth?) fauna. Jour. Mamm., 35: 249–252.

———. 1955. The Jinglebob interglacial (Sangamon?) fauna from Kansas and its climatic significance. Univ. Mich., Mus. Paleont., Contr., 12: 179–228.

Howell, A. B. 1927. Revision of the American lemming mice. N. Amer. Fauna 50: 1–38.

Lawrence, B. 1942. The muskrat in Florida. Proc. New England Zool. Club, 19: 17–20.

Simpson, G. G. 1928. Pleistocene mammals from a cave in Citrus County, Florida. Amer. Mus. Novitates, 328: 1–16.

———. 1929. Pleistocene mammalian fauna of the Seminole Field, Pinellas County, Florida. Bull. Amer. Mus. Nat. Hist., 56 (8): 561–599.

———. 1945. The principles of classification and a classification of mammals. Bull. Amer. Mus. Nat. Hist. 85: 1–350.

Wood, A. E. 1955. A revised classification of the rodents. Jour. Mamm., 36: 165–187.

Florida Geological Survey, Tallahassee. Received June 8, 1957.

THE BACULUM IN *LAGURUS* AND RELATED MICROTINES

By Lyle C. Dearden

The use of the baculum as an aid to the taxonomist has been a rather recent trend. Although Gilbert (1892), Tullberg (1899) and Didier (1943) described, illustrated and used the character of the baculum in comparative studies of Old World microtine rodents, no all-inclusive study of the baculum of the North American Microtinae has, to my knowledge, appeared in the literature. Hamilton (1946) published the most complete study of the baculum in these species. Ognev (1950: 552) pictured and described the baculum of *Lagurus lagurus* (Pallas). Burt (1936) suggested that the internal location of the baculum does not expose it to the rigorous environmental pressures of the appendicular skeleton or skull. Further, Burt (*op. cit.*) concluded that the baculum should be indicative of the true affinities of the animal.

In the present study, bacula were obtained from the three presently named species of the genus *Lagurus*, as well as from each of the subspecies of *L. curtatus* occurring in North America. In addition, bacula from other genera of microtine rodents, namely *Lemmus, Dicrostonyx, Synaptomys, Clethrionomys, Phenacomys* and *Microtus* have been obtained and are herein contrasted and compared with bacula in the genus *Lagurus*. A total of 75 bacula have been studied in the preparation of this paper.

Variation of the baculum in animals belonging to the genus *Lagurus* is most often seen when comparing the baculum from animals of different age groups. In newborn, juvenile and subadult animals, the baculum is thinner dorsoventrally and less widened laterally. In these age groups, the distal digital processes are in various stages of differentiation from the complete cartilaginous to the bony stage. In adult animals, variation is discernible primarily with reference to the distal tip of the shaft, the base of the median digit and the base of the bacular shaft. These adult variations do not, however, overlap to such an extent as to hinder definite identification at the specific level. Differentiation of the baculum of the subspecies of *L. curtatus* is, in some cases, as distinct as at the specific level. Frequently, however, the degree of variation found in the baculum of closely related populations overlaps to such an extent that positive identification is untenable.

Materials and methods.—The bacula were obtained from dried skins, and from alcoholic specimens from my own collections. These structures were dissected, stained and mounted in balsam (White, 1951) or embedded in cold-setting polyester casting plastic. To prepare the plastic for use, several drops of Duoprox (tertiary butyl hydroperoxide) were added to and thoroughly mixed with the plastic. Duoprox serves as a catalyst to speed up the time required for the cold-setting plastic to harden. In the plastic method, the early preparatory stages followed the method of White (*op. cit.*). After clearing in glycerin, the bacula were dried momentarily, immersed in acetone, and subsequently transferred to a multiple hanging-drop slide which had been lightly greased and

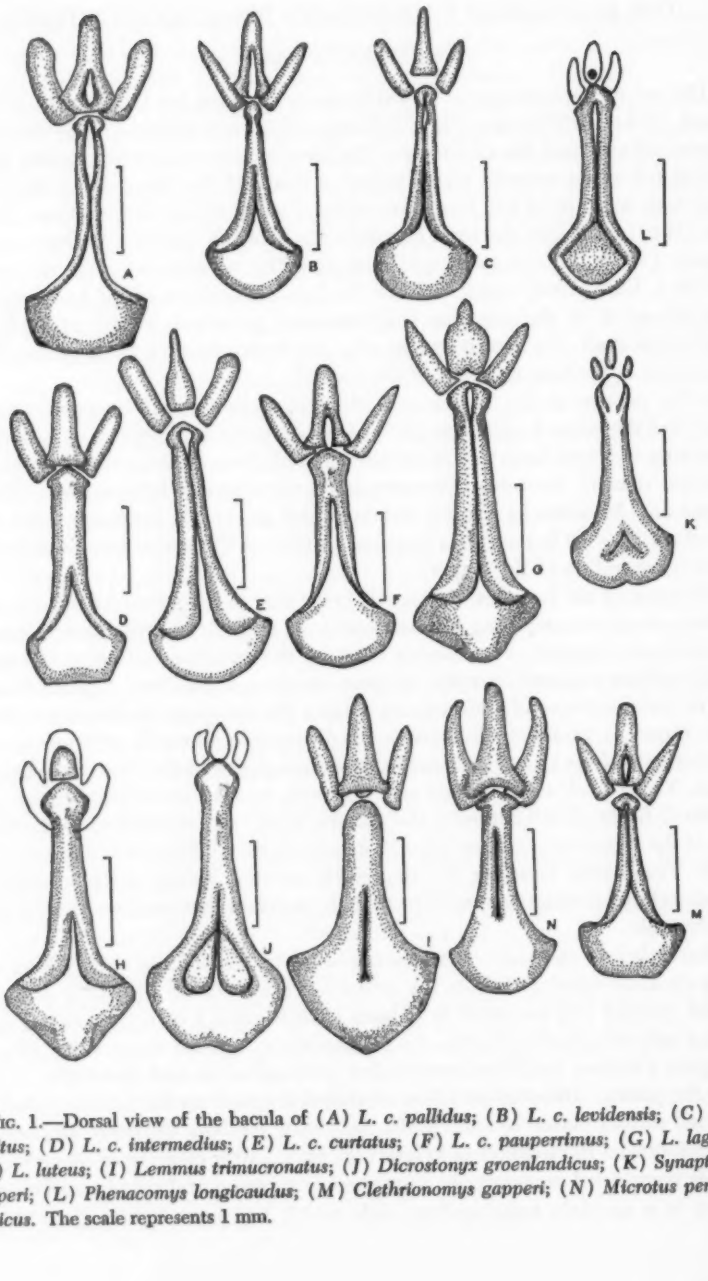

FIG. 1.—Dorsal view of the bacula of (A) *L. c. pallidus*; (B) *L. c. levidensis*; (C) *L. c. orbitus*; (D) *L. c. intermedius*; (E) *L. c. curtatus*; (F) *L. c. pauperrimus*; (G) *L. lagurus*; (H) *L. luteus*; (I) *Lemmus trimucronatus*; (J) *Dicrostonyx groenlandicus*; (K) *Synaptomys cooperi*; (L) *Phenacomys longicaudus*; (M) *Clethrionomys gapperi*; (N) *Microtus pennsylvanicus*. The scale represents 1 mm.

TABLE 1.—*Analysis of variance of the length of the bacular shaft in Microtus, Clethrionomys, Lemmus and Lagurus*

	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
Groups	3	0.51	0.17
Individuals	11	0.269	0.024
$F = \frac{0.17}{0.024} =$	7.083	$F = \left[\begin{matrix} 3 \\ 11 \end{matrix} \quad 0.01 \right] = 6.22$	

covered with a basal layer of plastic. The basal layer containing the baculum was hardened with the aid of ultraviolet light and a second layer of plastic was added. The entire preparation was capped with a lightly greased slide and allowed to completely solidify; this required a period of from two to three days. The use of ultraviolet light should not exceed a total of three minutes. Prolonged use of ultraviolet light causes the plastic mounts to harden too rapidly and, consequently, the preparation usually cracks. The advantages of the plastic embedding method are twofold: (1) Identification tags containing the specimen number and name may be placed between the first and second layers of plastic; (2) the refractive index is greatly increased and consequently more detail can be visualized.

Drawings of the bacula were made with the aid of the bioscope.

Description of the baculum.—In animals of the genus *Lagurus*, the baculum (Fig. 1) is composed of a basal shaft, markedly enlarged and widened proximally, and three digit-like processes distally. The base of the shaft is slightly to moderately concave on its ventral surface. On the dorsal surface there is usually a poorly defined keel. This bony structure is located in the glans penis. The trident distal end of the baculum becomes completely ossified in adult specimens of *L. lagurus* and *L. curtatus*. In *L. curtatus* the lateral digits begin to ossify prior to the median digit. I was unable to determine which digit ossifies first in *L. lagurus* because of insufficient bacula of the proper age groups. In *L. luteus*, only the median digit is ossified.

In *L. c. pallidus*, the baculum (Fig. 1*A*) is larger than in all other races of this species. (For measurements, see Table 7.) The base of the shaft is rectangular. The distal end of the shaft is semicircular and flattened on the ventral side. In this latter respect, there is a distinct resemblance to this structure in *L. luteus*. The base of the median digit is markedly angular and has a distinct ridge on its dorsoproximal surface.

In *L. c. levidensis*, the baculum (Fig. 1*B*) is smaller than in all other subspecies of *L. curtatus*. (For measurements, see Table 7.) The base of the shaft is nearly semilunar in shape. The base of the median digit is semilunar in configuration. There is a distinct ridge on the dorsoproximal surface of the median digit. In this respect, these animals are similar to those of *L. c. pallidus*.

The baculum of *L. c. orbitus* (Fig. 1*C*) is of medium size. (See Table 7.) The base of the shaft is semicircular in outline, but not as deep as in *L. c. levidensis*.

TABLE 2.—*Length of bacular shaft*

GENERA	MEAN	STANDARD ERROR
Microtus	2.53	$\sqrt{\frac{0.024}{3}} = 0.0894$
Clethrionomys	2.166	$\sqrt{\frac{0.024}{3}} = 0.0894$
Lemmus	2.75	$\sqrt{\frac{0.024}{3}} = 0.0894$
Lagurus	2.46	$\sqrt{\frac{0.024}{6}} = 0.0633$

$$K_o = \frac{1}{N-1}\left(SK - \frac{SK^2}{SK}\right)$$

$$K_o = \frac{1}{4-1}\left(15 - \frac{63}{15}\right)$$

$$K_o = 3.6$$

$$Ts = \left(q\sqrt{\frac{S^2}{K_o}}\right)$$

$$Ts = \left(4.3\sqrt{\frac{0.024}{3.6}}\right) \text{ at 5 per cent}$$

$$Ts = 0.357$$

$$Ts = \left(5.5\sqrt{\frac{0.024}{3.6}}\right) \text{ at 1 per cent}$$

$$Ts = 0.457$$

The distal tip of the shaft is markedly knob-like. The base of the median digit is flat and distinctly removed from the distal end of the shaft. There is no ridge present on the dorsoproximal surface of the median digit.

In *L. c. intermedius*, the baculum (Fig. 1*D*) is slightly larger than in *L. c. levidensis*, and slightly smaller than in *L. c. orbitus*. (See Table 7.) The base of the shaft is subrectangular and distoproximally shortened. In this respect, the baculum of animals of this subspecies is similar to those of *L. c. pallidus*.

The baculum in *L. c. curtatus* (Fig 1*E*) is large, nearly as large as that of *L. c. pallidus*. (See Table 7.) The base of the shaft is similar to that of *L. c. levidensis*. The distal tip of the shaft is semilunar in shape. The bony part of the base of the median digit is distinctly removed from the distal end of the shaft. In this respect, *L. c. orbitus* and *L. c. curtatus* are similar.

In *L. c. pauperrimus*, the baculum (Fig. 1*F*) presents characters which, on the one hand, are similar to those of *L. c. curtatus* and *L. c. levidensis* and, on the other, resemble those of *L. c. pallidus*. In the former, the base of the shaft is usually cup-shaped but, in one case, tends toward the rectangular shape seen in the baculum of *L. c. pallidus*. Moreover, the dorsoproximal surface of the median digit has a well-developed ridge which is similar to the ridge seen on the median digit in *L. c. levidensis* and *L. c. pallidus*. The distal end of the shaft is knob-like.

TABLE 3.—*Analysis of variance of the width of the base of the bacular shaft in Microtus, Clethrionomys, Lemmus and Lagurus*

	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
Groups	3	0.560	0.186
Individuals	11	0.279	0.025
$F = \frac{0.186}{0.025} =$	7.44	$F = \left[\begin{smallmatrix} 3 \\ 11 \end{smallmatrix} \; 0.01\right] = 6.22$	

The base of the median digit, in adult animals, is flat. In this respect, this characteristic is similar to the condition seen in *L. c. curtatus* and *L. c. orbtus*. (See Table 7.)

In *L. lagurus*, the baculum (Fig. 1G) is larger than in the North American representatives of this genus. (See Table 7.) Moreover, these bacula are immediately separated from the bacula of *L. curtatus* by the unusual shape of the median digit. In these voles (*L. lagurus*) the distal end of the median digit is narrow and the sides are nearly parallel for approximately one-third the length of the median digit. The proximal two-thirds of the median digit enlarge markedly laterad, and maintain this width to the base of the median digit. The base of the median digit tends to be slightly heart-shaped. Ognev (1950: 552) pictured a small additional bony segment between each lateral digit and the bacular shaft. I have been unable to locate this segment in the bacula of *L. lagurus* available to me. Moreover, Ognev (*loc. cit.*) portrays the baculum of a subadult or juvenile animal and, since the adult structure and the juvenile structure of the baculum of these animals is markedly different, the illustration of Ognev and my own presentation are not in agreement.

In *L. luteus*, the digital processes of the baculum are extremely short with only the basal part of the median digit ossified. (Fig. 1*H*). The base of the shaft is wider than in all other species of the genus. (See Table 7.) The distal tip of the shaft is broadly deltoid and flattened ventrally. The presence of the ossified median digit and no bony lateral digits is markedly different from the condition seen in the other species of this genus. The extremely short digital processes are indicative of a rather close relationship to *Dicrostonyx* and *Synaptomys*. Argyropulo (*fide* Ognev, *op. cit.*: 554) has suggested that *L. luteus* and the subspecies *L. l. prezewalskii* be singled out to form a special subgenus *Eolagurus*. On the basis of the dissimilarities of the bacula in *L. luteus*, *L. lagurus* and *L. curtatus*, the former species would seem to warrant subgeneric designation.

In *Lemmus trimucronatus*, the baculum is large and robust (Fig. 1*I*). (See Table 7.) The base of the shaft is deeply cup-shaped; the tip is distinctly oval. The base of the median digit has a lateral prong on each side and a slight mid-basal protuberance. All three digits are elongate and not typical of the digits of the bacula of other members of the tribe Lemmini. The affinities of the bacula of these lemmings lie with those of *Microtus pennsylvanicus*.

The baculum in *Dicrostonyx groenlandicus* (Fig. 1*J*) is distinctive and mark-

TABLE 4.—*Width of the base of the bacular shaft*

GENERA	MEAN	STANDARD ERROR
Microtus	1.1416	$\sqrt{\frac{0.025}{3}} = 0.0911$
Clethrionomys	1.211	$\sqrt{\frac{0.025}{3}} = 0.0911$
Lemmus	1.536	$\sqrt{\frac{0.025}{3}} = 0.0911$
Lagurus	1.055	$\sqrt{\frac{0.025}{6}} = 0.0640$

$$K_s = \frac{1}{3}\left(15 - \frac{63}{15}\right)$$

$$K_s = 3.6$$

$$Ts = \left(4.3\sqrt{\frac{0.025}{3.6}}\right) \text{ at 5 per cent}$$

$$Ts = 0.357$$

$$Ts = 0.457 \text{ at 1 per cent}$$

edly different from the baculum in all other Microtinae. The shaft tends to be rather stout. The base of the shaft is broad and distinctly concave ventrally. The shape of the base of the shaft is irregular, sometimes rounded, sometimes angular, and according to Hamilton (1946: 381) may have condylar knobs on the lateral extremities of the base. These condylar knobs are not evident in the bacula of *Dicrostonyx* available to me. There is a distinct ridge or keel on the distal half of the ventral surface of the shaft. A prominent knob-like protuberance is present at the distal end of the shaft. The digital processes are extremely short in comparison to these structures in most other Microtinae. In the bacula available to me, the digits are all cartilaginous. Hamilton (*op. cit.*) has reported that the lateral digits are partly ossified, but that the median digit is not ossified in any of the bacula of *Dicrostonyx* available to him. Since the bacular shaft appears to have reached full development in my specimens, it appears that the ossification of the lateral digits may not commence until the animals are fully adult. Moreover, it appears that the median digit may remain cartilaginous throughout the lifetime of the individual. (See Table 7.)

The baculum of *Synaptomys cooperi* (Fig. 1K) is in many ways similar to that of *Dicrostonyx*. In general configuration, the shaft, base of the shaft and digital processes of the bacula of these genera are similar. In the former genus, however, the distal tip of the shaft tends to be slightly longer distoproximally. The digits are slightly smaller and, in contrast to those of *Dicrostonyx*, are completely ossified. (See Table 7.)

The bacula of *Phenacomys longicaudus* are markedly different from that of *Phenacomys longicaudus* as pictured by Hamilton (1946: 379). In his illustra-

TABLE 5.—*Analysis of variance of the length of the bacular shaft in Lagurus curtatus*

	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
Groups	5	2.16	0.43
Individuals	29	3.04	0.1048
$F = \frac{0.43}{0.1048} =$	4.10	$F = \left[\begin{matrix} 5 \\ 29 \end{matrix} \quad 0.01 \right] = 3.73$	

tion, Hamilton shows the distal digital processes ankylosed to the distal end of the shaft. Moreover, he describes and illustrates the base of the shaft as triangular. In the bacula of *Phenacomys longicaudus* (Fig. 1*L*), neither are the digital processes ankylosed to the shaft, nor is the base of the shaft triangular. The distal digital processes of the bacula in the latter species are always short and in close proximity with, but not ankylosed to, the distal end of the shaft. The base of the shaft is semilunar and distinctly concave on the ventral surface. Moreover, the proximal part of the shaft, as it joins the base of the shaft, appears to be connected by means of two divergent legs. These legs are interconnected by a thin bony lamina. There is a rather prominent keel on the distodorsal surface of the shaft. This keel diminishes proximally to its point of origin at the union of the divergent legs of the shaft. The digits of the bacula are cartilaginous. There is, however, a small center of ossification at the base of the median digit. No centers of ossification are present in the lateral digits. (See Table 7.)

The baculum in *Clethrionomys gapperi* (Fig. 1*M*) is strikingly similar to this structure in *Lagurus curtatus*. The base of the shaft is subrectngular to cup-shaped. Distally the shaft tapers markedly. The digital processes are rather long, with a distinct dorsal ridge on the median digit. The dorsoproximal ridge may be long, extending proximally to the distal tip of the shaft, or may be short and only reach the base of the median digit. Since this ridge is absent in the baculum of juvenile animals, it seems that this structure is indicative of adult animals only. (See Table 7.)

In *Microtus pennsylvanicus* the baculum (Fig. 1*N*) is quite robust. The base of the shaft is broad, cup-shaped and slightly concave ventrally. The distal tip of the shaft (in adults) is notched bilaterally just proximally to the distinct knob-like terminal end. The lateral digits are long, narrow and curved medially. These digits are attached to the shaft just proximally to the knob-like distal tip of the shaft. The median digit is subtriangular with prominent lateral prolongations at the base. The base of the median digit is curved distally to accommodate the distal tip of the shaft. (See Table 7.)

Development of the baculum in L. curtatus.—The baculum has its anlage as a cartilaginous precursor in the glans penis. Following birth, ossification centers become identifiable in the digits and shaft. These ossification centers are located as follows: One in the base of the shaft; two in the median digit; two in each lateral digit. Ossification is first seen in the base of the shaft, with the shaft and digits remaining cartilaginous. The base of the shaft is not completely ossified

TABLE 6.—*Length of the bacular shaft*

SUBSPECIES OF *L. curtatus*	MEAN	STANDARD ERROR
pallidus	2.746	$\sqrt{\frac{0.1048}{3}} = 0.187$
levidensis	1.960	$\sqrt{\frac{0.1048}{12}} = 0.0933$
orbitus	2.34	$\sqrt{\frac{0.1048}{3}} = 0.187$
intermedius	2.06	$\sqrt{\frac{0.1048}{3}} = 0.187$
curtatus	2.48	$\sqrt{\frac{0.1048}{4}} = 0.162$
pauperrimus	2.36	$\sqrt{\frac{0.1048}{10}} = 0.102$

$$K_s = \frac{1}{5}\left(35 - \frac{287}{35}\right)$$

$$K_s = 5.36$$

$$Ts = \left(4.3\sqrt{\frac{0.1048}{5.36}}\right) \text{ at 5 per cent}$$

$$Ts = 0.61$$

$$Ts = 0.732 \text{ at 1 per cent}$$

prior to the initial stages of ossification of the shaft. Ossification proceeds distally from the base of the shaft. The digital processes remain cartilaginous during the period of ossification of the shaft, and continue in such a state during the early juvenile growth period. During later growth periods, ossification of the lateral digits commences from two proximally located centers of ossification. As in the shaft, ossification proceeds distally. The median digit, however, begins ossification from either a distal tip center or from the proximal center, prior to complete ossification of the lateral digits. Ossification of the median digit is more rapid than that of the lateral digits and is completed prior to, or at about the same time as, the bony elements of the lateral digits reach the terminal part of the ensheathing cartilaginous envelope. Moreover, complete ossification of the baculum is not obtained until the animal has reached the adult stage. Therefore, growth of the baculum may be used as an additional age-determining factor. Thus, newborn animals possess bacula with only the base of the shaft ossified; in juvenile animals, the shaft is ossified but the digital processes remain cartillaginous; in subadult animals the shaft is completely ossified and the beginnings of ossification are evident in the median and lateral digits; adult animals are evidenced by complete ossification, with the distal ends of the lateral digits usually being the last to receive bony elements. These age findings

TABLE 7.—*Measurements of bacula in mm.*
N = number of specimens; $\bar{X}$ = mean; R = range of measurements

MICROTINE RODENTS	LENGTH OF SHAFT			WIDTH OF BASE OF SHAFT			LENGTH OF MEDIAN DIGIT			WIDTH OF BASE OF MEDIAN DIGIT		
	N	$\bar{X}$	R	N	$\bar{X}$	R	N	$\bar{X}$	R	N	$\bar{X}$	R
L. c.			2.96			1.72			1.11			0.39
pallidus	3	2.75	2.50	3	1.21	0.77	3	1.0[illegible]	0.85	2	0.38	0.36
L. c.			2.59			0.83						0.45
levidensis	12	1.96	1.60	4	0.81	0.79	4	0.79	0.79	4	0.37	0.32
L. c.			2.51			1.06			0.84			0.23
orbitus	3	2.35	2.20	3	1.01	0.95	3	0.8[illegible]	0.80	3	0.22	0.22
L. c.			2.36						0.86			0.41
intermedius	3	2.29	2.22	3	1.11	1.11	3	0.[illegible]	0.79	3	0.35	0.32
L. c			2.88			1.29			1.14			0.50
curtatus	4	2.48	2.05	4	0.97	0.70	4	0.9[illegible]	0.84	3	0.33	0.30
L. c.			2.88			1.31			1.16			0.44
pauperrimus	9	2.41	2.18	9	1.05	0.74	7	0.9[illegible]	0.77	7	0.35	0.25
			2.71			1.14						
L. luteus	4	2.89	3.08	4	1.29	1.44						
			3.04			1.18			0.77			0.40
L. lagurus	3	2.88	2.75	3	1.11	1.06	3	0.7[illegible]	0.74	3	0.39	0.38
Dicrostonyx			3.10			1.61						
groenlandicus	3	2.95	2.85	3	1.54	1.50						
Synaptomys			2.62			1.60			0.31			
cooperi	3	2.56	2.48	4	1.53	1.48	3	0.3[illegible]	0.30			
Lemmus			2.71						1.13			
trimucronatus	2	2.69	2.68	1	1.55	1.55	2	0.9[illegible]	0.86	1	0.43	0.43
Phenacomys			2.70			1.81						
longicaudus	3	2.61	2.53	3	1.76	1.67						
Clethrionomys			2.86			1.52			0.93			0.43
gapperi	6	2.18	1.50	6	1.02	0.40	5	0.8[illegible]	0.75	5	0.37	0.26
Microtus			2.78			1.66			1.16			0.60
pennsylvanicus	4	2.56	2.42	4	1.39	1.13	4	1.0[illegible]	0.99	3	0.57	0.53

are, for the most part, corroborated by skull measurements, wear on the occulusal surface of the teeth and the union of suture patterns in the skull.

The appearance of the dorsoproximal ridge on the median digit in *L. c. pallidus, L. c. levidensis* and *L. c. pauperrimus* evidently occurs only in extremely old individuals.

Statistical analysis.—Statistical analysis of various measurements of the baculum of microtine rodents has been employed in an attempt to more clearly analyze the morphological differences noted. Because of the similarity of the bacula in *Lagurus, Clethrionomys, Microtus* and *Lemmus,* these genera have been compared statistically at the generic level. The bacula in *L. curtatus* are, in many respects, diagnostically divergent enough to warrant statistical consideration at the subspecific level.

In these studies, the length of the shaft, the width of the base of the shaft, the length of the median digit and the ratio of the length of the median digit to the width of the base of the median digit have been statistically analyzed at the generic and subspecific levels. It is worthy of note that no significant difference

was obtained, by means of analysis of variance, at either generic or subspecific levels in studies of the length of the median digit and the ratio of the length of the median digit to the width of the base of the median digit. In contrast, however, statistical analysis of the width of the base of the shaft and the length of the shaft were significant at the generic level. At the subspecific level, only the length of the shaft proved to be statistically significant.

In all cases where a significant difference was obtained, Tukey's test of least significance (*Ts*) was employed to ascertain the significant difference between the means of any two of the populations analyzed. In the equations that follow, q is the range of K treatments divided by the standard deviation of the treatments. K_0 is a constant, SK is the sum of the individuals, SK^2 is the sum of the squares of K treatments, and S^2 is the mean square of individuals.

From Table 1, it is readily ascertained that the F value for the length of the bacular shaft is significant, thus indicating more than one population. It is noteworthy that, by means of the Tukey test, the bacula of animals of the genus *Clethrionomys* are significantly different from the bacula of animals of the genus *Lemmus* at the 1 per cent level. At the 5 per cent level, the bacula of *Clethrionomys* are significantly different from those of *Microtus*. The fact that the bacula of these animals (*Clethrionomys*) are not significantly different from those of the genus *Lagurus* seems to indicate a rather close relationship between these genera.

Table 3 shows that the F value for the width of the base of the bacular shaft is significant, thus indicating more than one population among the genera considered. Further, by means of Tukey's test, the bacula of *Lagurus* are significantly different from those of *Lemmus* at the 1 per cent level, and significantly different from those of *Microtus* at the 5 per cent level. Since the bacula of *Lagurus* and *Clethrionomys* are not significantly different at either the 1 per cent or 5 per cent levels, it appears that these groups are rather closely related.

The significant F value in Table 5 indicates that more than one population is present among the *L. curtatus*. Moreover, Tukey's test indicates that the bacula of *L. c. levidensis* are significantly different from those of *L. c. pallidus* at the 1 per cent level. Further, the bacula of *L. c. intermedius* and those of *L. c. pallidus* are significantly different at the 5 per cent level.

Discussion.—The types of bacula found in the subfamily Microtinae can be divided into two groups; bacula with short digital processes, and bacula with long digital processes. Included in the former group are such animals as *Dicrostonyx, Synaptomys, Phenacomys, L. luteus* and, from the illustration of Hamilton (1946: 379), *Pitymys pinetorum*. The latter group is composed of *Microtus, L. curtatus, L. lagurus, Clethrionomys, Lemmus* and, from Hamilton's work (*op. cit.*), *Ondatra* and *Neofiber*. Within each group considerable variation occurs relative to the lack of ossification in certain of the digits and with reference to which digits ossify first. In animals possessing bacula with short digits, *Dicrostonyx* and *L. luteus* are representatives of this group which apparently evidence no sign of ossification of the median digit in the case of the former, and of the

lateral digits in the case of the latter. It is worthy of note that the median digit in the baculum of *Phenacomys longicaudus* begins to ossify prior to the lateral digits. The unossified median digit in the baculum of *Neofiber alleni* (Hamilton, 1946: 383) represents the only variant of ossification relative to the digital processes in animals possessing bacula with long digital processes. The lateral digital processes of the baculum in *L. curtatus* commence ossification prior to the median digit. Hamilton (*op. cit.*: 381) states that, with the exception of *Dicrostonyx*, it is the median digit of the baculum which ossifies first in other microtines.

Within the group of animals possessing bacula with short digital processes, *Dicroxonyx* and *Synaptomys* appear to be rather closely related. The bacula from these animals differ with reference to the lack of ossification of the median digit and in the presence of the keel on the ventral surface of the shaft in *Dicrostonyx*.

In *Phenacomys longicaudus*, the baculum differs from all other microtine rodents in the unusual shape of the tip of the bacular shaft and in the leg-like appearance of the distal part of the base of the shaft. The bacula from these rodents are similar to those of previous genera in the possession of short digital processes.

The lack of ossification of the lateral digits of the baculum in *L. luteus* is diagnostic. The relationships of these animals are referred to the former genera primarily on the basis of the short digital processes.

The classification of microtine rodents into the tribes Lemmini and Microtini is not appropriate if the bacula are used to show their respective affinities. According to my observations, these rodents may be phylogenetically arranged from most primitive to most advanced, and compared with the classification of these rodents by Simpson (1945: 87) as follows:

Dicrostonyx
Synaptomys
Phenacomys
Lagurus
Subgenus *Eolagurus*
L. luteus
Subgenus *Lagurus*
L. lagurus
Subgenus *Lemmiscus*
L. curtatus
Clethrionomys
Microtus
Lemmus

Tribe *Lemmini*
Dicrostonyx
Synaptomys
Lemmus
Tribe *Microtini*
Clethrionomys
Ondatra
Neofiber
Phenacomys
Pitymys
Microtus
Lagurus

According to this arrangement, the genus *Lemmus*, considered by Simpson (*loc. cit.*) to be one of the more primitive microtines, is far removed from its original phylogenetic position and becomes one of the most advanced of the microtine rodents. In the above phylogenetic arrangement, the genus *Lagurus* merits special consideration. In *L. luteus*, the baculum is so distinctly different

from this structure in the other species of this genus, that their close relationship is immediately questionable. Moreover, the affinities of the baculum in *L. luteus* are closely related to those of *Dicrostonyx, Synaptomys* and *Phenacomys*. In this arrangement, the genus *Lagurus* is much more primitive rather than the most specialized genus of the North American members of the subfamily Microtinae. Further, Hinton (1926) suggested that animals of the genus *Lagurus* have been derived from some *Phenacomys*-like ancestor. The above classification seems to give credence to Hinton's suggestion. Since this study is primarily related to the genus *Lagurus*, the subgenera and species of the genus are shown in their respective phylogenetic positions.

The bacula in *Microtus pennsylvanicus, Clethrionomys gapperi, L. curtatus* and *L. lagurus* are, in general appearance, basically similar. The affinities of the baculum of *Lemmus trimucronatus* lie with the aforementioned group. Statistical analysis of the bacula of these genera indicates that *Clethrionomys* and *L. curtatus* are most closely related.

Within the subspecies of *L. curtatus*, statistical analysis of the length of the bacular shaft reveals that *L. c. levidensis* and *L. c. pallidus* are significantly different at the 1 per cent level. Regardless of the similarity of the median digit of the baculum of these two subspecies, the bacula are readily distinguished when their gross aspects are considered. Although the ranges of distribution of these two populations are contiguous, no specimens from areas of possible intergradation have been obtained since the early 1900's. It may be that these races are geographically isloated and morphologically distinctive enough to warrant specific designation.

The present classification of microtine rodents is only tentative. Additional data on the bacula of other species and on genera not included in the present study will serve to further clarify the taxonomy of the subfamily Microtinae.

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SUMMARY

Burt (1936) has suggested that the true affinities of mammals might best be ascertained by means of comparative studies of their bacula. In the present study, I have described and compared the bacula of *Dicrostonyx groenlandicus, Synaptomys cooperi, Lemmus trimucronatus, Phenacomys longicaudus, Lagurus luteus, L. lagurus, L. curtatus, Clethrionomys gapperi* and *Microtus pennsylvanicus*. Statistical analysis of various measurements of the bacula have been used wherever possible to substantiate morphological differences noted. The changes of the baculum in *L. curtatus* from the newborn to the adult have been described.

Significant conclusions derived from this study are listed as follows: (1) The bacula in *L. luteus* are so diagnostically divergent from those of *L. lagurus* and *L. curtatus* that the former species has been separated from the subgenus *Lagurus*, and now comprises the new subgenus *Eolagurus*; (2) the genus *Lagurus* is a primitive rather than an advanced member of the subfamily Microtinae; (3) the tribes Lemmini and Microtini are not valid taxonomic entities if the affinities of the bacula are considered indicative of close phylogenetic relationship; (4) the phylogenetic classification of microtine rodents based upon comparative studies of the baculum is markedly diverse from the presently accepted classification of this subfamily.

LITERATURE CITED

BURT, WILLIAM HENRY. 1936. A study of the baculum in the genera *Perognathus* and *Dipodomys*. Jour. Mamm., 17: 145–156.

DIDIER, ROBERT. 1943. L'os penien des campagnols de France du genre *Arvicola*. Mammalia, 7: 74–79.

GILBERT, T. H. 1892. Das Os priape der Saugethiere. Morph. Jahrb., 18: 805–831.

HAMILTON, W. J., JR. 1946. A study of the baculum in some North America Microtinae. Jour. Mamm., 27: 378–387.

HINTON, M. A. C. 1926. Monograph of the voles and lemmings (Microtinae) living and extinct. Brit. Mus. Nat. Hist., London, 488 pp.

OGNEV, S. I. 1950. The mammals of U.S.S.R. and adjacent countries. Vol. VII, Rodentia, Microtinae. Moscow, 707 pp.

SIMPSON, GEORGE GAYLORD. 1945. The principles of classification and a classification of mammals. Bull. Amer. Mus. Nat. Hist., 85: xvi + 350 pp.

TULLBERG, T. 1899. Ueber das System der Nagethiere, eine Phylogenetsche Studie. Nov. Acta. Reg. Soc. Upsala, ser. 3, vol. 18: 329–541.

WHITE, JOHN A. 1951. A practical method for mounting the bacula of small mammals. Jour. Mamm., 32: 125.

Dept. of Anatomy, School of Medicine, Univ. of Southern California, Los Angeles. *Received March 20, 1957.*

SEROLOGICAL EVIDENCE ON THE RELATIONSHIPS OF THE MUSK OX

By Paul A. Moody

Opinions concerning the relationships of the musk ox to other members of the family Bovidae are varied and contradictory. Flower and Lydekker (1891) stated that "this genus is generally considered to be a connecting link between the Caprine and Bovine sections, but should rather be regarded as an aberrant type of the former." Yet the idea, suggested indeed by the very name *Ovibos*, that the genus forms a link betwen sheep and cattle has never completely disappeared (*cf.* Glover, 1953).

The genus received monographic treatment by Allen (1913) who, largely on the basis of the morphology of the Recent forms, concluded that "*Ovibos* finds its nearest ally among living mammals in the genus *Bison*." This view has been largely followed by mammalogists (*cf.* Anthony, 1928; Seton, 1929). On the other hand, paleontologists have concluded that *Ovibos* is most closely allied to goats. Thus Simpson (1945) placed *Ovibos* in the subfamily Caprinae; Miller and Kellogg (1955) followed his usage in doing so. Seemingly paleontologists have been influenced to this view by study of related Old World genera, especially *Urmiatherium*, *Parurmiatherium*, *Criotherium* and *Plesiaddax*, which combine to bridge the gap between ovibovine and caprine characteristics (Pocock, 1918; Sickenberg, 1933; Bohlin, 1935; Schwarz, 1937; Pilgrim, 1939). That the controversy is still current is attested by Tome XVII of Grassé, Traité de Zoologie. One contributor to this volume on mammals places the musk ox in the subfamily Bovinae (Frechkop, 1955) while a few pages later another contributor classifies it in the subfamily Caprinae (Lavocat, 1955). This diversity of practice in one volume lends point to the comment by Pilgrim (1939): "*Ovibos* has been bandied about like a shuttlecock between the two groups of the oxen and the sheep."

When morphology of recent and extinct forms is inconclusive in establishing relationships, serology sometimes proves helpful. The serum proteins seem to behave as conservative characters amid evolutionary change. By serological means, for example, Boyden and Gemeroy (1950) demonstrated the affinity of the whales to the Artiodactyla, Moody, Cochran and Drugg (1949) demonstrated that lagomorphs and rodents are not closely related mammals, and Moody and Doniger (1956) showed that the African and North American porcupines are but slightly related rodents, each the product of independent evolution.

The present investigation is an attempt to shed serological light on the controversy as to whether the musk ox has bovine or caprine affinities. The investigation was made possible by the enthusiastic cooperation of John J. Teal, Jr., Director of the Institute of Northern Agricultural Research, Huntington Center, Vermont, to whom I am most grateful.

MATERIALS AND METHODS

Antigens.—Antigens employed were the normal sera of musk ox (*Ovibos*) from a female specimen captured in the District of Mackenzie, Northwest Territories of Canada, domestic goat (*Capra*), domestic sheep (*Ovis*), domestic cattle of Aberdeen Angus breed (*Bos*), American bison (*Bison*), and Rocky Mountain goat (*Oreamnos*). The first four were supplied by the Institute of Northern Agricultural Research through the cooperation of Mr. Teal and Dr. Ernest F. Paquette. The last two were supplied by the Serological Museum of Rutgers University. I wish to thank Dr. Alan A. Boyden, the Director, and also the original collectors from the Rocky Mountain Laboratory of the U.S. Public Health Service: William L. Jellison, C. B. Phillips, and Betty Locker.

Antisera.—Three antisera were prepared, one each against musk ox, beef, and domestic goat serum. Each antiserum was the pooled serum from two (in the case of the goat, three) male domestic fowl each of which had received a total of 9.3 ml. of whole serum in a series of nine subcutaneous injections given over a period of six weeks.

Testing.—The precipitin test as measured with the Libby Photronreflectometer was employed (Libby, 1938). Since the technique of this test as performed in our laboratory has recently been described (Moody and Doniger, 1956) and since our technique is similar in principle to that described by Leone and Wiens (1956), I shall not describe it in detail here. Briefly, a series of doubling dilutions of each antigen was prepared, starting with one part of whole serum diluted with sixteen parts of 12 per cent salt solution. To each dilution of each series a constant quantity of antiserum was added. The mixtures were incubated at constant temperature for a standard time (Moody and Doniger, 1956) and the amount of turbidity that developed as a result of antigen-antibody reaction was measured photoelectrically. Little or no turbidity appeared in the first dilution of each series since antigen was present in too-high concentration to favor precipitate formation. In the highest dilution of each series there was also no turbidity, since antigen was present in too-low concentration to produce visible reaction. The dilutions between these extremes developed varying amounts of turbidity depending upon how closely optimal proportions of antigen and antibody were approached.

As a measure of the magnitude of the complete reaction the turbidity readings obtained with all dilutions of a series were added together. These totals are given in Table 1. Each test was repeated at least three times; the table contains the averages of these repeated tests. To facilitate comparisons the total turbidity readings were converted to percentages, the magnitude of the homologous reaction (that of an antiserum with the antigen against which it was formed) being designated as 100 per cent in each instance. These percentages are also given in Table 1 and are expressed in the form of a bar graph in Fig. 1, for the drawing of which I am indebted to Melton M. Miller, Jr.

RESULTS AND CONCLUSIONS

Anti-musk ox serum.—Since antisera change slowly with age and since the sheep and Rocky Mountain goat sera were not available for testing at the same time, or at the same time as the other antigens, it seemed best to repeat the homologous test each time new heterologous tests were run. This explains the three values for the homologous test included in Table 1.

The tests with this antiserum show clearly that the musk ox is much more similar serologically to the sheep and the two goats (magnitude of reactions varying between 50.9 and 75.2 per cent) than it is to beef and bison (10.9 and 7.4 per cent, respectively). In referring to *Capra* and *Oreamnos* as "two goats" I am temporarily overlooking the fact that the mountain "goat" is probably more closely allied to the chamois than it is to the domestic goat. Nevertheless, the antiserum revealed the serological similarity of the musk ox to both of them. The results also suggest that the musk ox is more closely related to sheep than to goats (Fig. 1) but additional tests, including reciprocal tests with anti-sheep serum, will be needed before positive statements can be made on this point.

Anti-goat serum.—Domestic goats and sheep are generally recognized as closely related animals, although hybridization between them is doubtful. Gray (1954) states that "controlled experiments have invariably failed to produce live young." Closeness of relationship was reflected in the serological tests, sheep serum giving a 76.7 per cent reaction with anti-goat serum (Table 1). Previous investigations have also shown strong serological similarity between sheep and goat (Wolfe, 1939; Baier and Wolfe, 1942).

The reaction with musk ox serum (60.8 per cent) was next in magnitude to that with sheep serum. Thus the anti-goat serum, like the anti-musk ox serum, indicated relatively close relationship between musk ox and goat. It is to be noted that the magnitude of the reciprocal reactions is similar also: goat serum

TABLE 1.—*Results of tests with the three antisera. Data are in terms of galvanometer units at a photronreflectometer reference-setting of 50. Each sum is the mean of three or more repetitions of a test and is accompanied by its standard error. Each percentage represents the relationship of a heterologous test to the homologous test performed with the antiserum*

ANTIGENS	ANTI-MUSK OX SERUM		ANTI-GOAT SERUM		ANTI-BEEF SERUM	
	Sum of turbidities	Percentage	Sum of turbidities	Percentage	Sum of turbidities	Percentage
Musk ox	693.0 ± 12.2	100.0	662.7 ± 3.5	60.8	308.7 ± 18.0	25.4
Sheep	428.5 ± 13.9	75.2*	835.6 ± 31.8	76.7		
Goat	444.5 ± 24.8	64.1	1089.0 ± 20.1	100.0	278.5 ± 10.0	22.9
Rocky Mt. goat	269.7 ± 19.1	50.9†			268.3 ± 14.6	22.1
Beef	75.8 ± 7.7	10.9	195.7 ± 9.3	18.0	1216.6 ± 53.3	100.0
Bison	51.5 ± 6.3	7.4	130.0 ± 15.1	11.9	898.5 ± 14.5	73.9

* Homologous test totaled 569.7 ± 9.1 at this time.
† Homologous test totaled 529.3 ± 29.0 at this time.

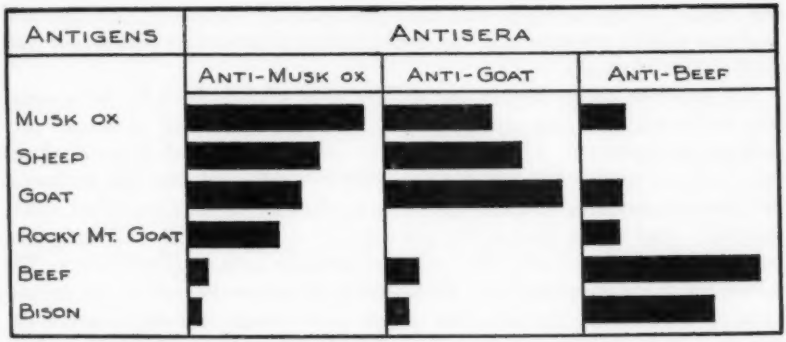

FIG. 1.—Serological relationships of six members of the family Bovidae as evidenced by reciprocal tests with three antisera. Based on percentages given in Table 1.

gave a 64.1 per cent reaction with anti-musk ox serum; musk ox serum gave a 60.8 per cent reaction with anti-goat serum.

The anti-goat serum reacted to a magnitude of only 18.0 and 11.9 per cent, respectively, with beef and bison sera. This smaller reaction reflects the wisdom of separating goats and cattle in classification, as by placing them in separate subfamilies, Caprinae and Bovinae (*cf. also* Baier and Wolfe, 1942).

Anti-beef serum.—As was to be expected, the largest heterologous reaction of this antiserum was with bison serum (73.9 per cent). This strong reaction reflects the known close relationship of beef and bison, a fact attested by the occurrence of hybridization, though with F_1 male sterility (Gray, 1954). Previous serological investigations have also revealed this closeness of relationship (e.g., Baier and Wolfe, 1942). Of greatest interest in the present connection are previous results obtained with the photronreflectometer method of measurement. Boyden and DeFalco (1943) employed an anti-beef serum and obtained cross reactions of 74 and 73 per cent with two specimens of bison serum. Gemeroy, Boyden and DeFalco (1955) obtained a 74.4 per cent reaction of bison serum with anti-beef serum. Schmedtje (1956), employing two anti-beef-gamma-globulin sera, obtained readings of 76 and 91 per cent when testing with bison serum. Except for the one higher reading in this last investigation the magnitudes of these reactions are remarkably similar, a fact that tends to instill confidence in the validity of serological tests applied to systematics. This agreement is all the more interesting when we note that the present anti-beef serum was produced in domestic fowl while the anti-beef sera used in the other investigations were produced in rabbits. Despite differences which at times arise from individuality of response on the part of antibody producers, valid conclusions concerning relationships can be drawn from serological data.

The anti-beef serum gave reactions of 22 per cent with the two goat sera. This percentage agrees well with the 18 per cent obtained in the reciprocal

test (beef serum reacting with anti-goat serum). Gemeroy, Boyden and DeFalco (1955) obtained a 28 per cent reaction of mountain goat serum with their anti-beef serum.

The anti-beef serum reacted but slightly more strongly with musk ox serum than it did with the goat sera (Table 1). The apparent small difference may well not be significant. Thus, this antiserum like the anti-musk ox serum shows that beef and musk ox are not closely similar in serum proteins. The reciprocal percentages are not in so close agreement as they are in instances cited above, however. Beef serum gave a 10.9 per cent reaction with anti-musk ox serum, while musk ox serum gave a 25.4 per cent reaction with anti-beef serum. The reason for this discrepancy is to be sought in difference in potency of the two antisera concerned. The anti-beef serum had a high antibody content (as reflected in the 1216.6 homologous reaction; Table 1) while the anti-musk ox serum was much weaker (693). Boyden and DeFalco (1943) demonstrated that the relative magnitude of heterologous reactions declines progressively as antisera are diluted (i.e., become weaker). Accordingly, I ran one experiment in which I diluted the anti-beef serum until its homologous reaction was reduced to 587.8. At this dilution the antiserum gave a 10.4 per cent reaction with musk ox serum, in close agreement with the 10.9 per cent obtained when the "naturally" weak anti-musk ox serum reacted with beef serum. These results emphasize the point that reciprocal agreement between weak heterologous reactions can only be expected when the two antisera concerned have similar potency of antibody content (as was true of the present anti-beef and anti-goat sera).

SUMMARY

Reciprocal precipitin tests were performed with three antisera (anti-musk ox, anti-goat, anti-beef). The tests were measured with the Libby Photronreflectometer. All tests agreed in indicating that the musk ox is serologically similar to sheep and goats and markedly dissimilar to domestic cattle and to bison. Indeed the results suggest that the musk ox may be nearly as closely related to sheep and goats as the latter are to each other or as bison is to beef. It would be interesting to determine whether or not the musk ox can be hybridized with sheep or goats (with production of sterile males, perhaps).

The present results support the practice of those systematists who indicate in some way that the musk ox is allied to sheep and goats, as was done by Simpson (1945) who placed them all in the subfamily Caprinae, separating them into the tribes Ovibovini and Caprini (with *Oreamnos* in the tribe Rupicaprini).

LITERATURE CITED

ALLEN, J. A. 1913. Ontogenetic and other variations in muskoxen, with a systematic review of the muskox group, recent and extinct. Memoirs, Amer. Mus. Nat. Hist. n.s., 1, pt. IV: 101–226, 18 pls.

ANTHONY, H. E. 1928. Field book of North American mammals. New York: G. P. Putnam's Sons. 625 pp.

BAIER, J. G., JR. AND H. R. WOLFE. 1942. Quantitative serologic relationships within the Artiodactyla. Zoologica, 27: 17–23.

BOHLIN, B. 1935. Cavicornier der Hipparion-Fauna Nord-Chinas. Palaeontologia Sinica, series C, 1, fasc. 4: 1–166, 20 pls.

BOYDEN, A. AND R. J. DEFALCO. 1943. Report on the use of the photronreflectometer in serological comparisons. Physiol. Zool., 16: 229–241.

BOYDEN, A. AND D. GEMEROY. 1950. The relative position of the Cetacea among the orders of Mammalia as indicated by precipitin tests. Zoologica, 35: 145–151.

FLOWER, W. H. AND R. LYDEKKER. 1891. An introduction to the study of mammals living and extinct. London: A. and C. Black.

FRECHKOP, S. 1955. Sous-ordre des ruminants ou sélénodontes. *In* Grassé, P.P. (ed.), Traité de Zoologie. Tome XVII, fasc. 1: 568–667. Paris: Masson et Cie.

GLOVER, R. 1953. The muskox (*Ovibos moschatus*). Oryx, 2: 76–86.

GEMEROY, D., A. BOYDEN AND R. DEFALCO. 1955. What blood is that? Serological Museum, Bull. 14: 6–8.

GRAY, A. P. 1954. Mammalian hybrids. Bucks, England: Commonwealth Agricultural Bureaux.

LAVOCAT, R. 1955. Ruminants fossiles. *In* Grassé, P. P. (ed.), Traité de Zoologie. Tome XVII, fasc. 1: 668–690. Paris: Masson et Cie.

LEONE, C. A. AND A. L. WIENS. 1956. Comparative serology of carnivores. Jour. Mamm., 37: 11–23.

LIBBY, R. L. 1938. The photronreflectometer—an instrument for the measurement of turbid systems. Jour. Immunol., 34: 71–73.

MILLER, G. S., JR. AND R. KELLOGG. 1955. List of North American Recent mammals. U.S. Natl. Mus., Bull. 205: 1–954.

MOODY, P. A., V. A. COCHRAN AND H. DRUGG. 1949. Serological evidence on lagomorph relationships. Evolution, 3: 25–33.

MOODY, P. A. AND D. E. DONIGER. 1956. Serological light on porcupine relationships. Evolution, 10: 47–55.

PILGRIM, G. E. 1939. The fossil Bovidae of India. Palaeontologia Indica, n.s., 26: 1–356. 8 pls.

POCOCK, R. I. 1918. On some external characters of ruminant Artiodactyla. Pt. II. The Antilopinae, Rupicaprinae, and Caprinae, with a note on the penis of the Cephalophinae and Neotraginae. Ann. Mag. Nat. Hist., ser. 9, 2: 125–144.

SCHMEDTJE, J. F. 1956. A study of the reactions of anti-beef gamma globulin sera with the sera of representative even-toed ungulates. Serological Museum, Bull. 16: 2–3.

SCHWARTZ, E. 1937. Die fossilen Antilopen von Oldoway. Wiss. Ergeb. Oldoway-Exp. 1913. N. F. Heft 4: 7–90. 3 pls.

SETON, E. T. 1929. Lives of game animals. New York: Doubleday, Doran & Co., vol. 3: 595–637.

SICKENBERG, O. 1933. *Parurmiatherium rugosifrons*, ein neuer Bovide aus dem Unterpliozän von Samos. Palaeobiologica, 5: 81–102, 2 pls.

SIMPSON, G. G. 1945. The principles of classification and a classification of mammals. Bull. Amer. Mus. Nat. Hist., 85: 1–350.

WOLFE, H. R. 1939. Serologic relationships among Bovidae and Cervidae. Zoologica, 24: 309–321.

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A PRELIMINARY STUDY OF THE UNGAVA CARIBOU

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Northern Quebec and Labrador together form a block of about 500,000 square miles popularly known as the Ungava, or Labrador, Peninsula. It is cut off from the remainder of North America by the Gulf of St. Lawrence and Hudson and James bays. The topography is extremely varied. From a rough central plateau of about 2,000 feet elevation, large rivers drain in four directions to salt water. There are several mountain ranges; the highest—the Torngats—reach above 5,000 feet. Coastal plains are found in the north.

Geologically the peninsula forms the eastern portion of the Canadian Shield, which embraces Hudson and James bays like a giant horseshoe. Bedrock is composed principally of Archean quartz and gneiss, but in the interior a belt of Proterozoic (Huronian) sedimentary rocks occurs in the valleys of the Hamilton and Kaniapiskau rivers.

Four main vegetative zones have been described for the area by Hustich (1949). The Southern Boreal Forest extends along the north shore of the Gulf of St. Lawrence as far as the Labrador boundary. North of this belt the Labrador Taiga extends from a line drawn between the southern tip of James Bay and and the Labrador boundary on the north shore of the Gulf, northward to approximately the 55th parallel. The most northern forest type is called the Forest-Tundra, and extends from the 55th parallel to the south shore of Ungava Bay. The fourth zone, the Tundra, is divided into two portions by Ungava Bay. The western Tundra lies north of tree-line, which extends from Richmond Gulf to Leaf Bay. The eastern Tundra covers the rugged highlands of northern Labrador east of the George River, Quebec.

Rousseau (1952*a*) revised these areas somewhat. He adopted the following comparative terminology for the same vegetative zones: Tempérée, Subarctique, Hémiarctique and Arctique. Hare (1950) considered that the Forest-Tundra zone of Hustich was an ecotone between the Taiga and Tundra. After extensive flights over the peninsula, we have come to the same conclusion. It appears to us that altitude and drainage play the most important roles in determining whether a site supports a forest or tundra vegetation. It does not seem to us that the Forest-Tundra is an ecological unit which merits description. Rousseau (1952*a*) refers to the local ecotones surrounding the last islands of trees as the "Toundra forestière habitat."

There are some marked differences in climate between the Ungava Peninsula and northwestern Canada. The peninsula is large enough for its central regions to experience a continental climate with cold winters and relatively hot summers. However, the climate of the Labrador coast feels the moderating influence of the sea. There is also a marked difference in the amount of precipitation, especially the annual snowfall. The mean annual snowfall over most of the Northwest Territories is less than 60 inches. In the Ungava Peninsula it

varies approximately from 80 to 200 inches according to Thomas (1953). The highest precipitation occurs in southern Labrador.

It is difficult to obtain a clear appreciation of caribou numbers, distribution and migrations in the past. Unfortunately the exploration record is not nearly as complete for the Ungava Peninsula as for the Northwest Territories. We are forced to piece together fragmentary notes of early authors; even after the notes have been collated, we are left with only a hazy outline and many gaps.

At present the taxonomic status of the various herds of caribou in the peninsula is uncertain. Eastern woodland caribou, *Rangifer caribou caribou* (Gmelin), are thought to inhabit the river systems which flow into the Gulf of St. Lawrence, the Eagle River drainage of southern Labrador, and the valleys of the rivers which flow into James Bay as far north as the Fort George River. Farther north, Ungava caribou, *Rangifer caboti* Allen, are thought to inhabit the valleys of the streams which drain west into Hudson Bay and north to Ungava Bay, as well as that part of Labrador north of the Hamilton Inlet. A review of the relationships between these populations is presently under way.

Summarizations of caribou distribution have been made by Low (1897) and Elton (1942). It was Low who first described the Ungava caribou as comprising three herds. The western herd was supposed to spend the winter in the vicinity of Richmond Gulf and Clearwater Lake and migrate northward to spend the summer along the highlands of the northeast coast of Hudson Bay. The central herd crossed the lower part of the Koksoak River and spent the summer on the west side of Ungava Bay and Hudson Strait. The third, or eastern, herd moved from its winter grounds south of Lake Michikamau to summer ranges on the highlands between Nachvak and Nain.

Elton accepted Low's theory as a working model in order to interpret the historical records. There was probably an exchange of bands of caribou between herds and it is difficult to prove now that the herds were discrete, but Elton pointed out that a separate Indian band was in attendance on each herd, which lends support to the theory of separate herds. In a scholarly review of the historical information and unpublished records of the Hudson's Bay Company and Moravian Missions, Elton (1942) traced the changes in numbers, distribution and movements of the caribou which formerly occupied Quebec and Labrador north of the 53rd parallel. The interested reader is referred to his report for a documented review of the diminution of Ungava caribou numbers before 1942.

RECENT STUDIES

Within recent years, a number of biological expeditions have been undertaken in the Ungava Peninsula. The investigators have published brief reports upon their caribou observations which have served to kindle new interest in the present status of the caribou herds.

Doutt (1954) made a number of trips to the east coast of Hudson Bay for the Carnegie Museum. He visited the Seal Lakes during the summer of 1938,

and saw a few caribou tracks between Clearwater Lake and Lower Seal Lake. His Indian Guide reported that a small herd of about 30 to 40 caribou inhabited the region. The guide himself had killed 10 between Clearwater Lake and Upper Seal Lake during the summer of 1934. Doutt spent the spring and summer of 1945 in the vicinity of Povungnituk. During April and May, he saw several bands of 20 or more caribou on an inland trip by dog-sled. In the summer of 1953, Doutt again led a party to the Seal Lakes. This time they saw only a few recent tracks. Some fresh tracks were followed unsuccessfully by his Indians. Doutt found the bones of several caribou killed the previous winter.

Manning (1946) collected information on bird and mammal distribution at 12 mainland sites along the Hudson Bay coast and in the interior of the peninsula during the summer of 1944. He observed fresh tracks of caribou (woodland?) only at Lake Muskalagan on the Manicougan River. Manning also undertook a preliminary survey of the literature concerning caribou distribution in the peninsula for the Canadian Social Science Research Council. He published a preliminary report (Manning, 1948).

Rousseau (1948) descended the George River during the summer of 1947. During his survey, he saw about 25 caribou. In 1948, he crossed from Povungnituk to Payne Bay via the Kogaluk and Payne rivers (Rousseau, 1948). During the traverse only three caribou were seen in the Payne River drainage. In 1949, he visited the Otish Mountains, and reported that signs of caribou were plentiful. He became interested in the conservation and management of Ungava caribou after his field work and published a number of papers calling for conservation of the herds (Rousseau, 1950, 1951, and 1952*b*).

Dunbar (1950) obtained information on caribou distribution and utilization from interviews with local residents at Fort Chimo, which indicated excessive utilization and continued caribou decline in the George River area.

PRESENT INVESTIGATION

The Minister of Fish and Game for the Province of Quebec approached the Minister of Northern Affairs and National Resources in 1953 for assistance in undertaking a cooperative survey of the caribou population in northern Quebec. In 1954, a cooperative study was initiated, with biologists of the Quebec Department of Fish and Game and the Canadian Wildlife Service taking part. Field investigations were concluded in the spring of 1956.

The objective of the investigation was to determine the caribou numbers, distribution and population trend and to assess the factors responsible for the trend.

Some recent caribou distribution data were already available from aerial waterfowl surveys conducted by officers of the United States Bureau of Sport Fisheries and Wildlife in 1952 and 1953, and have been used with their permission.

A preliminary aerial survey was conducted by Clement Delisle and A. W. F. Banfield, during the period from April 9 to 21, 1954, to make a first assessment of caribou distribution and numbers. The reconnaissance route led from Roberval, Quebec to Nichequon, Knob Lake, Indian House Lake, Fort Mackenzie, Fort Chimo, Payne Bay, Indian House Lake, Goose Bay, Seven Islands, and back to Roberval.

Summer field investigations were conducted by Jacques Normandin and A. W. F. Banfield during the period July 25 to August 20, 1954. Field camps were established at Payne Lake, July 27 to August 4; Fort Chimo, August 4 to 10; and Indian House Lake, August 10 to 16. The tundra range was also surveyed by air from Fort Chimo to Payne Bay, Lake Nantais, Payne Lake, Lake Minto, Larch River, George River, Torngat Mountains, Indian House Lake, and back to Fort Chimo.

Further ground studies were conducted during the summer of 1955 by Claude Mainguy and J. S. Tener from June 28 to July 20. Aerial reconnaissance of tundra ranges was undertaken from Fort Chimo to Lower Seal River, Leaf River, Fort Chimo, George River, Abloviak Fiord, and Ford River. A field camp was established on the lower George River from June 30 to July 13, and quantitative range studies were conducted from it.

The final aerial survey of winter ranges was conducted by Normandin and Banfield from March 17 to 29, 1956. This reconnaissance covered the east coast of Hudson Bay. The flights led from Moosonee, Ontario to Great Whale River, Quebec, Lac Bienville, Richmond Gulf, Port Harrison, Povungnituk, Klotz Lake, Minto Lake, Port Harrison, Great Whale River, and Moose Factory.

Significant information on caribou numbers was obtained only on the spring aerial surveys of 1954 and 1956. Very few caribou were observed during the summer investigations. The aerial survey technique used has been described by Banfield *et al.* (1955). Altogether 10,650 miles of aerial reconnaissance were flown and 620 caribou observed.

Information on caribou numbers, distribution and utilization was obtained by interviews with Eskimos, Indians, traders, missionaries and Royal Canadian Mounted Police personnel at the twelve settlements visited.

CARIBOU NUMBERS

The present observations do not clearly fit into Low's description of three herds. However, an attempt has been made to show the relationships of the present herds with those of his analysis, for the purpose of continuity. The caribou were observed in small, loosely knit herds during the winter months. Not all such herds may have been discovered during the current investigation. However, inquiries and subsequent flights failed to produce evidence of any other significant groups. The herds were assigned names from the localities at which they were observed and have been tentatively allocated to Low's three herd groups as follows:

Species	*Low's Herd*	*Present Herd*
Rangifer caboti	Western	1. Western
" "	Central	2. Larch River
		3. Kaniapiskau R.
		4. Wheeler River
		5. Whale River
" "	Eastern	6. George River
Rangifer caribou	Southern	7. Mealy Mountains
		8. Mecatina–Natashquan

Estimates obtained from the aerial survey were used for five herds shown in Table 1. Since only 26 caribou were observed in the western area and the Larch and Mecatina-Natashquan herds were identified only by tracks, population estimates for those three herds were based upon track counts and reports from other observers. The total population of caribou in the Ungava Peninsula was estimated to be about 6,000.

DISTRIBUTION

Western herds.—The herds in western Ungava are in the most critical state. There are now only a few isolated herds in the interior from Lac Bienville to the headwaters of the Port Harrison River. The situation during the winter of 1955–56 may be outlined as follows. Two Indian trappers at Lac Des Voeux south of Lac Bienville are reported to have killed seven caribou, the first they had seen for many years. Pilots observed two caribou near Lac Bienville and we saw their tracks. At Richmond Gulf we learned that an Eskimo had killed nine near his camp on the south shore of Lac Minto. A small herd of caribou had migrated from the interior to within 35 miles of the coast near the Langland River where 40 were observed by J. Houston, Northern Service Officer, in January, 1956. They were killed later by Eskimo hunters from Port Harrison. We observed a herd of 22 on the Port Harrison River. Nearby, seven hides were stretched out on the snow at an Eskimo camp. Natives at Povungnituk reported that there were no caribou inland from that settlement. This was

TABLE 1.—*Estimate of caribou herd populations in Ungava*

NUMBER	HERD	TOTAL AREA, SQ. MILES	TRANSECT AREA	CARIBOU OBSERVED	TOTAL ESTIMATED CARIBOU
1	Western	—	—	22	250*
2	Larch River	—	—	—	200*
3	Kaniapiskau River	350	58	82	500
4	Wheeler River	230	38	82	500
5	Whale River	1,000	70	154	2,200
6	George River	2,400	248	206	2,000
7	Mealy Mountains	220	48	59	270
8	Mecatina–Natashquan	—	—	—	200*
Total					6,120

* Estimates not based upon aerial census.

substantiated by Cst. Wilson, R.C.M.P., who had just completed an overland patrol to Sugluk, Wakeham Bay, and return. He had seen no signs of caribou during the trip.

During August, 1956, Dr. McClement of McMaster University accompanied R.C.A.F. helicopter flights across the peninsula. He observed approximately 100 caribou in scattered groups between the headwaters of the Du Gue River and Upper Seal Lake, and approximately 50 between the headwaters of Rivière Serigny and Lac Bienville. In June, 1954, Armand Boudoin observed a small group of six east of Lac Nantais. Our aerial reconnaissance in July failed to find any caribou there, but a few fresh tracks were seen in the Lac Becard area. The last caribou reported near the coast were seen at Cape Weggs by a Topographic Survey team in 1949.

It is unlikely that there are many more than 250 Ungava caribou in the western area at present.

Central herds.—Very little seems to be known now concerning caribou distribution in the center of the peninsula. The three herds discovered in the area during the April, 1954, survey—the Kaniapiskau, Wheeler, and Whale River herds—have been tentatively assigned to this group of Low's. The Whale River herd may be part of the George River herd. When seen, however, it was migrating northwestward, which should have led it toward the tundra hilltops between the Whale and George rivers, south of Ungava Bay, or to the western tundra. At Fort Chimo we learned that a few natives still hunt caribou up the Whale River valley occasionally.

The best-known herd of caribou remaining in the central district is usually found north of the Larch River about 100 miles southwest of Fort Chimo. It is regularly hunted by the Eskimos from that post. The Nascopie Indians of Fort Mackenzie generally hunt in winter in the Du Gue River valley where a few caribou are taken. Caribou have been seen regularly by pilots as far south as Lac Delorme. We saw nothing of those groups except tracks. Mr. Walton, Northern Service Officer at Fort Chimo, estimates the Leaf River herd at about 200.

There are very few records of summer observations of caribou in the central area. The waterfowl survey team observed a few individuals in the Lac Potherie and upper Kaniapiskau River areas in 1953. Caribou have been absent from the Payne Bay area and northward for a number of years.

Eastern herds.—The caribou herd found in the George River valley of Quebec and the Labrador interior is probably the largest remaining herd in the Ungava Peninsula. Its movements are quite well known because of the interest of Bob May of Fort Chimo, formerly Hudson's Bay Company post manager at George River. Rousseau (1949) traveled through its range in 1947, and described the habitat well. We were fortunate to obtain fairly good aerial coverage of this herd in April, 1954, as it migrated from its winter range.

Tracks, beds and feeding craters indicated that the herd had wintered on the Canairiktok River in Labrador. Trails led northwest toward Whitegull

and Mistastin lakes where we observed the migrating groups. The leaders had reached Indian House Lake. According to Bob May the herd generally finds summer range on the plateau about 20 miles east of the George River between the Slanting and Ford rivers. In August, 1954 we observed a few scattered animals from the Bridgeman Mountains south to Indian House Lake. The waterfowl survey teams observed scattered animals in the same area in July 1952 and 1953. Dr. McClement observed scattered herds totaling about 50 animals in the Labrador highlands south of Mistastin Lake.

Aerial reconnaissance was undertaken over the Torngat Mountains as far north as Abloviak Fiord. We found no caribou in the area, indeed the scarcity of trails compared with more southerly areas indicated that the tip of the peninsula was infrequently visited by caribou. Bob May reported that a family of Eskimos which camped at the head of the Korok Fiord managed to kill a few caribou regularly. The George River herd, however, seldom descends the river beyond 30 miles from the coast. The existence of a northeastern sanctuary for the caribou south of Cape Chidley must be regarded as mythical.

One noteworthy fact is evident from a consideration of the summer and winter observations of the northern caribou herds. They have been noted in close proximity in both seasons. This indicates that they no longer undertake the long migrations so famous in the past. The change in migration pattern is probably associated with the great decline in numbers, as it apparently was for the caribou herds west of Hudson Bay (Banfield, 1954).

Southern herds.—Although emphasis was placed upon the northern herds of Ungava caribou, some information was gathered on the distribution of woodland caribou along the north shore of the Gulf of St. Lawrence.

Tracks and beds observed during our survey of April, 1954 indicated that the Mealy Mountains herd had spent the winter on the shores of Etagaulet Bay, Lake Melville. We found it migrating southward and climbing towards the tundra tops of the Mealy Mountains at elevations of 3,000 to 3,700 feet.

H. R. Walters, Director of Wildlife for Newfoundland, reported that caribou have been found fairly commonly between Cartwright and Battle Harbour, during recent winters, and are reported to migrate inland in the summer. The waterfowl survey teams observed large numbers of caribou in the upper Eagle River drainage during the summers of 1952 and 1953. In 1952, they saw 89 caribou, mostly cows and calves.

We observed numerous caribou trails in the Natashquan and Mecatina valleys leading northwest in April, 1954. Earlier in March, Dr. H. Dean Fisher observed a herd of approximately 20 near the coast at Natashquan. The waterfowl survey team observed scattered caribou in southern Labrador near Lakes Michikamau and Ossokmanuan. These observations may be of a single herd and may indicate an annual migration pattern. The tracks indicated the passage of about 200 animals.

We observed the tracks and beds of isolated bands of caribou in the Baie Comeau, Lake Pepmuacan, Lake Peribonca and Onistagan areas. We also

received reports that woodland caribou were common in the Mistassini, Otish Mountains and Rupert River areas. A small herd was reported to have been seen on the Fort George River, 20 miles northwest of Nitchequon in February, 1954, by a pilot.

These observations seem to indicate an increase in the woodland caribou herds in central Quebec since Low's (1897) time.

CALF INCREMENT

Little information was obtained during the investigation on the period of parturition or rate of increase. The calf increment data obtained from observations on a number of scattered caribou bands have been summed. They should therefore be treated with caution.

The waterfowl survey crew observed 94 adults, thought to be cows, and 34 newborn calves during June, 1952, mostly in southern Labrador. These data give a calf increment of 36 per cent of adults at the time of parturition. Newborn calves were observed on June 8 and 14.

From aerial photographs taken in April, 1954, 142 caribou were segregated. Of these, 36 were short yearlings. The remaining animals appeared to be all cows, indicating a ratio of 34 short yearlings to 100 cows. A herd photographed north of Lake Minto in March, 1956, contained 15 adult cows and 7 short yearlings, or 47 short yearlings to 100 cows.

Although these samples are small, the observations all indicate a very high production and survival rate for caribou as compared with western Arctic herds (Banfield, 1954).

RANGE STUDIES

Much has been written about the luxurious lichen growth of the Ungava Peninsula. Hustich (1951), in particular, has presented factual information about the ecology and forage production of lichens in Ungava and Labrador. He concluded that lichen production in the woodland regions of these areas is unsurpassed anywhere in North America or Europe. This condition was due partly to the low caribou population which existed in Ungava for many years.

Plant collections were made at Payne Lake and on the plateau between the George and Ford rivers. At the latter site a range survey was also undertaken to determine the frequency of occurrence and coverage of plants growing there. Using the Raunkiaer circle method, 272 quadrats on the tundra plateau and 100 quadrats on the forested bench above the George River were examined. The partial results of the range studies are given in Table 2. They show that caribou food plants are common in occurrence and dense in coverage.

During a barren-ground caribou survey conducted in the Northwest Territories, Banfield (1954) undertook range surveys in a variety of vegetation types. In August, 1949 he sampled, by the Raunkiaer method, 300 quadrats from tundra near Lake Clinton-Colden. That area most closely resembles the one

TABLE 2.—*Comparison of two range vegetation studies in tundra habitats in Mackenzie District, N.W.T. and Northern Quebec*

SELECTED SPECIES	LAKE CLINTON-COLDEN, N.W.T.		GEORGE RIVER, QUEBEC	
	Frequency index	Coverage	Frequency index	Coverage
Shrubs:				
Willows, *Salix* sp.	.09	.018	.09	.013
Dwarf birch, *Betula glandulosa*	.21	.033	.38	.088
Picea mariana	—	—	.01	.004
Ground vegetation:				
Cetraria nivalis	.37	.014	.27	.027
Other lichens	.15	.028	.34	.088
Labrador tea, *Ledum decumbens*	.55	.084	.29	.010
Bilberry, *Vaccinium uliginosum*	.30	.040	.49	.065
Foxberry, *Vaccinium vitis-idaea*	.30	.024	.25	.011
Bearberry, *Arctostaphylos alpina*	.27	.041	.13	.014
Crowberry, *Empetrum nigrum*	.17	.029	.38	.067
Cloudberry, *Rubus chamaemorus*	.04	.002	.04	T
Sedges	.17	.022	.98	.034

surveyed on the George River, and is used for comparison in Table 2. The comparison reveals some interesting facts which support the visual observations of richer lichen growth in the latter area. In the Mackenzie District lichens were restricted to small clumps and scattered thalli. In the Ungava lichens occurred as a continuous carpet over large areas. This is reflected in the greater frequency and coverage figures from the latter site. The annual production must also be larger.

It is difficult to make further comparisons using the data presented in Table 2, as the floristic composition of the two areas differed somewhat. It is evident, however, that food requirements on summer and winter ranges do not limit caribou numbers at present in Ungava.

FOREST AND TUNDRA FIRES

The importance of forest fires in influencing caribou distribution and numbers in Ungava has long been recognized. Hind (1863) vividly described the destruction caused by forest fires in the Moisie and Ashuanipi river valleys. He reported that great fires had raged in these areas as well as in the Rupert River valley in 1785, 1814, 1857 and 1859. Some of the fires caused dense palls of smoke to lie over the Maritime Provinces. He found the country blackened, desolate and devoid of animal life when he reached Ashuanipi Lake in 1861. The woodland caribou had been exterminated and the Indians had starved. He reported that fires had increased since the Indians had received flints and matches from the Europeans. Carelessness with signal fires and campfires had resulted in the burning of much of the country immediately north of the St. Lawrence River.

The lichens important as sources of caribou food are exceedingly slow-growing. Rousseau (1949) has estimated that following destruction by fire it takes about 30 years to restore the lichen carpet. The thick carpet covering the Archean granitic rocks in Ungava becomes tinder-dry in the dry, hot summer months. Writers such as McLean (1849) and Hind (1863) have remarked on the explosive speed of fires spreading through the lichen forests in summer. Rousseau (1951) has also drawn attention to the prevalence of tundra fires. He concluded that they had seriously restricted the range of Ungava caribou.

Particular attention was paid to forest fire destruction of caribou ranges during our investigation. Observations were made from the air and on the ground. During the 1954 spring survey flights, totaling 4,560 miles, approximately 240 miles were flown across recently burned areas in which little or no spruce regeneration showed above the snow cover. This random flight sample indicates that about 5 per cent of the central and eastern forest habitat has been burned in the past 10 to 20 years. Most of the fires occurred along the north shore of the Gulf of St. Lawrence.

Recent burns were again mapped on the 1956 flights over the western forested regions. It was found that more of the climax forest along the east coast of Hudson Bay had been destroyed by fire during recent years—as much as 25 per cent. In some areas new growth barely showed above the snow.

At Great Whale River it was reported that an area approximately 150 miles long and 50 miles wide had burned during the summer of 1955. Smoke from that fire had hampered the 1955 aerial surveys east of Minto Lake. At Richmond Gulf it was reported that much of the forest between the gulf and Clearwater Lake had burned during the summer of 1954.

Five tundra fires were observed during field studies at Payne Lake. Four of them were less than one square mile in the area, the fifth was somewhat larger.

Rousseau (1951) thought that tundra fires in Ungava were set by men, but it is known that there were no people in the vicinity of the fires observed at Payne Lake. The lichens were dry and the fires may have started from lightning strikes, as the weather preceding and during the study period was hot and dry with scattered thunderstorms. Residents of the Fort Chimo area believed that quartz crystals in the rock focus sunlight on nearby lichens and set them

TABLE 3.—*Estimates of native utilization obtained during the investigation*

SETTLEMENT	1953–54	1954–55	1955–56
Fort George (Woodland)	—	—	7
Richmond Gulf	—	—	9
Port Harrison	—	50	100
Povungnituk	6	—	—
George River	—	69	70
Fort Mackenzie	40	—	—
Fort Chimo	10	46	20
Payne Bay	5	—	—

on fire. This may be so, as several tundra fires appeared to start simultaneously during hot dry spells.

The effect of a tundra fire was studied at close hand on the ground. Although the fire burned off the lichen carpet to a depth of 4 to 5 inches, the charred base of the vegetative mat was damp to the touch. Dampness from the permafrost line prevented the fire from penetrating deeply. It appeared that most of the vegetation, including the lichen bases, had been killed and that regeneration would be by exceedingly slow recolonization.

PREDATORS

Wolves (*Canis lupus*) and wolverines (*Gulo luscus*) were formerly numerous in the Ungava Peninsula when the caribou were abundant. Low (1897) wrote that wolves were scarce in the southern regions since the "extermination" of the caribou, but they were found in the northern barrens and semibarrens where the caribou were still plentiful. During the winter of 1893 many wolves were taken in the Hamilton River valley of Labrador. Wolverines were reported abundant throughout the Labrador. As the caribou population declined, so did the populations of wolves and wolverines. Elton (1942) reported that the number of caribou skins traded at the Labrador Moravian Missions dropped from 13,569 in the decade 1894–1903, to none in the decade 1914–1923. During the same two periods the number of wolf and wolverine hides trade dropped from 131 to 18. Strong (1930) reported that wolves were scarce in southern Labrador by 1928.

All residents interviewed during the study indicated that wolves were rare or absent in their areas. None was reported at Fort Chimo in 1954 and 1955. The Payne Bay natives saw only one track in the winter of 1954. The only sign of wolves noted from the air was tracks, tentatively identified, south of the Mealy Mountains in 1954. None was seen on the 1955 or 1956 flights. At present wolves appear to be more common in southern Labrador than in northern Ungava. This is the opposite to the situation described by Low (1897).

NATIVE UTILIZATION

The important role played by caribou in the culture and economy of Ungava natives has been described by Turner (1894) and other early writers. As the caribou population declined, the natives faced grave hardships and even starvation (Hind, 1863). The disappearance of caribou from the George River valley after 1916 (Strong, 1930) caused the Nascopie Indians to abandon the area.

As the caribou declined, it was natural for one group of natives to blame another group for the extermination. N. Ross, Hudson's Bay Company manager at Great Whale River, wrote in 1938 (Elton, 1942) that the Hudson Bay natives blamed the Fort Chimo natives for lying in wait near the height of land and killing the caribou as they migrated westward, thus forcing them to abandon their migration. In March, 1956 we heard the same sort of story from the

Povungnituk natives. They asserted that the Fort Chimo natives set fires along the Larch River and deflected the caribou migration from the western tundra.

Dunbar (1950) reported that the natives from Hebron, Labrador were slaughtering excessively the George River caribou herds. Bob May reported to us that he found 30 carcasses of caribou abandoned by Hebron natives during the summer of 1942, east of the George River.

During our investigations in April, 1954 we observed about ten igloos of hunting parties in the Mistastin Lake area of western Labrador. They were hunting caribou migrating northwestward toward the George River.

In recent years the native population of the Ungava Peninsula has increased. This causes greater pressure on the limited resources of the area. According to information from the Indian Affairs Branch (1954) and the Arctic Division of the Department of Northern Affairs and National Resources, the native population in the area frequented by caribou in northern Quebec is as follows: Crees, 2,782; Montagnais, 2,384; Nascopies, 191; Eskimos, 2,422. The Indian population in Labrador is thought to be about 300. There are probably, therefore, more than 10,000 natives in the area covered by this report.

It was formerly thought that the law of diminishing returns would apply to the native utilization of caribou: the number of caribou taken would decline as the caribou herds diminished in size, until it would not be worth while to hunt caribou. However, observation of Eskimo hunting at Port Harrison, Quebec in March, 1956 has shown that the hunters sometimes embark on caribou hunts that may last three to six weeks and involve 100 to 300 miles travel by dog team, and still be unsuccessful. When they find the tracks of a band of caribou they trail it day and night until all the caribou are killed or a storm obliterates the tracks. Often the hunters return to the settlement bringing only hides. The meat taken may not even have been enough for the hunters and the dogs during the hunt.

It may be that the Europeans at the settlements are encouraging the natives to obtain some fresh meat for everyone. Under these conditions, natives are exterminating the last herds of caribou in the western Ungava. Significantly large herds have continued to exist in the eastern highlands only because the natives have left the George River valley as a result of the scarcity of fur bearers and caribou.

The information on native utilization of caribou obtained by interviews with missionaries, traders, natives, police and northern service officers during our investigation is sketchy. Estimate of local kills is listed in Table 3, to give an approximation of the current rate of utilization.

SUMMARY

A number of factors have been blamed by previous authors for the decline in the caribou population. We have obtained recent information that permits a better evaluation of these factors.

Gosling (1910) reported that the sled dogs in Labrador suffered from a distemper

epizootic in 1859, which caused great mortality. He added, "even the caribou died in vast numbers from the same disease." It is difficult to evaluate this report at present. A number of caribou might have died of rabies in an epizootic of that disease but it is unlikely that the number would have been large enough to influence the population. We obtained no information on the present health of the caribou. A few warble flies (*Oedemagena tarandi*) were on the wing at Indian House Lake in August, 1954 and one was collected. None was seen at Payne Lake, reflecting the scarcity of caribou in that area.

The wolf population is too low at present to have a significant effect upon the caribou population.

Forest fires have played an important role in influencing caribou populations, according to Hind (1863) and Rousseau (1951). We found the winter ranges of the central and eastern herds of Ungava caribou and the woodland caribou herds of southern Labrador relatively intact. The winter ranges of the western herd have suffered great destruction from recent fires. It would not be possible to maintain very large herds of caribou along the eastern coast of Hudson Bay under present conditions.

Some authors (Flaherty and Flaherty, 1924) have suggested that a winter thaw and subsequent formation of an ice crust over the vegetation may have caused the caribou to starve. That may have happened on the Belcher Islands and in some local coastal areas, but the peninsula has a continental climate in the interior and it is unlikely that all of it would be so affected. Elton (1942) presented records to indicate that the winters in Labrador were generally mild after 1908 and the mildness may have influenced the caribou population. The general "warming" which has occurred in the eastern Arctic may have pushed climatic conditions beyond the optimum tolerances of caribou. Lacking accurate information on the tolerances of caribou, or the amount of the "warming," this point is difficult to decide.

The importance of native exploitation with firearms has long been recognized as an important factor in the decline. When Hind (1863) asked the Montagnais chief on the Moisie River when the caribou began to diminish, the Indian replied, "when white people bought skins and gave Indians guns—deer soon pass away." When we asked an Eskimo, Johnny Povungnituk, the reason for the decline, his reply was much the same, "guns, I guess." Elton (1942) concluded that the introduction of modern firearms to the Ungava Indians by traders about 1903 had been an important factor in the caribou decline. Jim Ford, of Payne Bay, reported that he had noticed a steady decrease since about 1926 and thought that the repeating rifle and forest fires had been responsible.

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LITERATURE CITED

BANFIELD, A. W. F. 1954. Preliminary investigation of the barren-ground caribou. Parts 1 and 2, Wildlife Management Bulls. 10A, 79 pp., 10B, 112 pp. Canadian Wildlife Service, Ottawa.

BANFIELD, A. W. F., D. R. FLOOK, J. P. KELSALL AND A. G. LOUGHREY. 1955. An aerial survey technique for northern big game. Trans. N.A. Wildl. Conf., 20: 519–532.

DOUTT, J. K. 1954. Observations on mammals along the east coast of Hudson Bay and the interior of Ungava. Ann. Carnegie Mus., 33: 235–249.

DUNBAR, M. J. 1950. The caribou of northeastern Ungava. Ann. Rept. Prov. Que. Assoc. Protect. Fish & Game, 91: 10–14.

ELTON, C. 1942. Caribou herds and modern trade. *In* Voles, mice and lemmings: problems in population dynamics. Oxford University Press, London. 496 pp.

FLAHERTY, R. J. AND F. H. FLAHERTY. 1924. My Eskimo friends: "Nanook of the North." Garden City, New York. 170 pp.

GOSLING, W. G. 1910. Labrador, its discovery, exploration and development. Musson, Toronto. 574 pp.

HARE, F. KENNETH. 1950. Climate and zonal divisions of the boreal forest formation in eastern Canada. Geol. Rev., 40: 615–635.

HIND, H. Y. 1863. Explorations in the interior of the Labrador Peninsula. Longmans Green. London. Vol. 1, 351 pp.

HUSTICH, I. 1949. Phytogeographical regions of Labrador. Arctic, 2: 36–42.

———. 1951. The lichen woodlands in Labrador and their importance as winter pastures for domestic reindeer. Acta Geog. 12: 1–48.

INDIAN AFFAIRS BRANCH. 1954. Census of Indians in Canada. Dept. of Citizenship and Immigration, Ottawa, 39 pp.

LOW, A. P. 1897. Report on explorations in the Labrador Peninsula, along the East Main, Koksoak, Hamilton, Manicuagan, and portions of other rivers, in 1892–95. Ann. Rept. Geol. Surv. Canada for 1895, 8: 1–387. App. L.

MANNING, T. H. 1946. Bird and mammal notes from the east side of Hudson Bay. Can. Field Nat., 60: 71–85.

———. 1948. Report on the caribou of the Ungava Peninsula. Ann. Rept. Prov. Que. Assoc. Protect. Fish & Game, 89: 20–21.

MCLEAN, J. 1849. Notes of a twenty-five years' service in the Hudson's Bay territory. London, Vol. 2: 25–166.

ROUSSEAU, JACQUES. 1948. The vegetation and life zones of the George River, eastern Ungava, and the welfare of the natives. Arctic 1: 93–96.

———. 1949. A travers l'Ungava. Montreal Botanic Garden, Memoir 4: 83–131.

———. 1950. Le caribou et le renne dans le Quebec Arctique et Hemiarctique. Rev. Canad. de Geogr., 4: 60–89.

———. 1951. Basic principles for the protection of the barren-ground caribou and reindeer breeding in Quebec. Ann. Rept. Prov. Que. Assoc. Protect. Game & Fish, 92: 28–35.

———. 1952*a*. Les zones biologiques de peninsule Quebec–Labrador et l'hemiarctique. Can. Bot. 30: 436–474.

———. 1952*b*. Les problems de conservation de l'Ungava et du Labrador. Can. Conserv. Assoc. Ann. Rept., 1952: 51–79.

STRONG, W. D. 1930. Notes on mammals of the Labrador interior. Jour. Mamm., 11: 1–10.

THOMAS, M. K. 1953. Climatological atlas of Canada. Dept. of Transport. Ottawa. 253 pp.

TURNER, L. M. 1894. Ethnology of the Ungava district. Hudson Bay territory. Smithson. Inst. Bur. of Am. Ethnol., Ann. Rept. 11: 167–349.

National Museum of Canada and Canadian Wildlife Service, Ottawa. Received July 25, 1957.

THE LAND MAMMALS OF THE KODIAK ISLANDS

By W. Kim Clark

How the few endemic mammals first became established on the Kodiak Islands, approximately 40 miles from the Alaskan mainland, is of course unknown. The presence of one flier and a strong swimmer or two could be explained easily, and a former ice or land bridge might account for the others, but this fails to explain the absence of other types found on nearby shores. Transportation by human residents of long ago is also a possibility.

Topography.—The area is comparable in size to that of New Jersey and Delaware. Deeply indenting, steep-sloped bays are numerous and nearly split the main island, Kodiak. Rocky peaks, generally ranging from 2000 to 3500 feet in elevation, are common and a few reach over 4000 feet. The southwestern ends of Kodiak and nearby islands are somewhat less rocky and of a lower, rolling nature. The northeastern parts of the group, northern Afognak and Shuyak islands, are also lower but rocky. The entire group appears to be an above-water portion of a marine ridge, extending southwestward from Kenai Peninsula, roughly paralleling the Alaska Peninsula and separated by the trough of Shelikof Strait (Fig. 1).

Vegetation.—A heavy cover of Sitka spruce (*Picea sitchensis*) covers Afognak Island and, in stunted form, Shuyak Island, but it only fringes the northeastern part of Kodiak. Except for a few scattered specimens of Sitka spruce, no other conifer is found on Kodiak. Black cottonwood (*Populus trichocarpa*) is found in stream bottoms except in the southwestern portion which is practically tundra. Willows (*Salix* spp.) and alder (*Alnus crispa*) clothe most slopes of the island. Berries, especially elderberry (*Sambucus racemosus pubens*) are fairly common. A luxuriant herbaceous growth, primarily bluejoint grass (*Calamagrostis canadensis*) and fireweed (*Epilobium angustifolium*) covers low areas each summer.

Weather.—The weather is generally cool and damp with many days of cloud-covered skies, resulting in mild winters and cool summers. Winds are commonly moderate but occasionally reach gale force.

Indigenous mammals.—In this environment the following six species of mammals are known to be endemic:

Little brown bat, *Myotis l. lucifugus* (Le Conte): This bat is fairly common in areas of dense spruce cover and some were also collected by Robert Rausch at Larsen Bay, well southwest of the spruce area. Whether this bat hibernates here is not definitely known. My earliest observation was on March 31, 1954; the latest record is of one observed in November, 1956, by Archie Mossman.

Tundra vole, *Microtus oeconomus kadiacensis* Merriam: Although much of the island group has been sampled by various collectors, this is the only mouse that has been captured. (Nor have any shrews been collected.) This microtine is abundant on Kodiak and all nearby islands of any size from sea level to the alpine areas as high as 3500 feet.

Kodiak red fox, *Vulpes fulva harrimani* Merriam: The typical yellowish form with large tail is found on the southwestern half of Kodiak and nearby islands; on the northeastern half, Afognak and nearby islands, a nearly equal mixture of red, cross and silver color variations is encountered. This may be due to admixture with escapees from fox farms. At present, fox trapping is nearly nonexistent

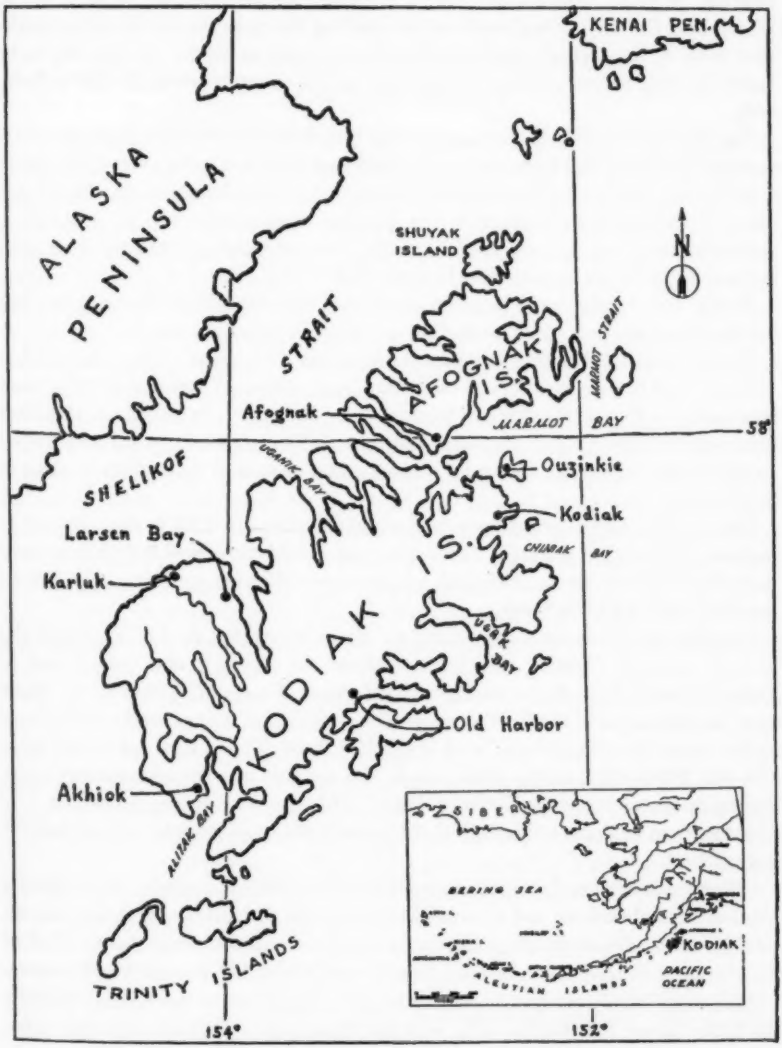

FIG. 1.—General map of the Kodiak Island Group.

because of low fur prices, and this has resulted in large fox populations. In their ranging for food, beaches are constantly visited.

Kodiak brown bear, *Ursus middendorffi* Merriam: This best-known of the Kodiak mammals ranges over the entire island group except the lower southwestern Trinity Islands and other smaller islands some distance offshore. Heavy hunting pressure, unnecessary illegal slaughter by commercial fishermen, and killing by a few struggling ranchers are holding this great omnivore to a population that, in the writer's opinion, is in the vicinity of 2,000. It appears to be barely holdng its own, with a current annual kill of approximately 200 individuals.

The Kodiak Wildlife Refuge, under the U.S. Fish and Wildlife Service, covers most of the main island except for the northeast area and a strip along the shore, a mile wide, under jurisdiction of the Bureau of Land Management. Hunting is allowed throughout the Refuge. At present, negotiations are in progress to withdraw the peninsula south of Ugak Bay from the Refuge and to place jurisdiction of the shore strip under the Fish and Wildlife Service.

Range and habitat have been little affected thus far. If anything, protective brushy cover appears to be increasing and food supplies are ample.

Kodiak weasel, *Mustela erminea kadiacensis* (Merriam): This mustelid is common and has been observed on all the large islands; I have seen individuals swimming as far as 100 yards in fresh water. Tundra voles afford an abundant food supply. On August 12, 1956, within a folded mattress in an abandoned cabin on Kodiak Island, I found a weasel cache or nest of more than 20 skins of these voles.

River otter, *Lutra canadensis kodiacensis* Goldman: This is the only other endemic mustelid in the area. It is often seen in salt water and is found in every part of the island group. Although trapped annually, it appears to maintain its numbers with little difficulty.

Introduced mammals.—According to Rausch (Arctic, 6: 124 f., 1953) the ground squirrel, *Citellus undulatus kodiacensis* (Allen), was introduced to Kodiak Island. Rausch quotes Howell (N. Amer. Fauna 56, 1938) to the effect that "the character of the Kodiak squirrel was such that it appeared to have been on the island for a long time;" and Hrdlicka (Publ. Wistar Inst. Anat. and Biol., 475–480, 1944) who, on the other hand, "did not find any ground squirrel bones during his excavations on Kodiak Island." This species appears numerous only near the town of Kodiak although there is much other apparently suitable habitat not utilized.

Other known introductions, especially in the 1920's, include the following species: snowshoe hare, red squirrel, beaver, muskrat, Norway rat, house mouse, mink, marten, Olympic elk, Sitka deer, reindeer and mountain goat. Most of these appear to have become established, except possibly the mink and marten.

Summary.—Only six species are definitely indigenous to the Kodiak Islands: the little brown bat, tundra vole, red fox, brown bear, weasel and river otter. Why others that are common on the nearby mainland—such as shrew, mink,

wolf, black bear, wolverine, moose and caribou—did not become established at some former time, makes for interesting conjecture.

U.S. Fish and Wildlife Service, Kodiak, Alaska. Received June 20, 1957.

ON THE STUDY OF AFRICAN MAMMALIA

By W. F. H. Ansell

As Meester (1954) very rightly points out, we have not yet by any means completed the "exploration and cataloguing stage" as far as African mammals are concerned. In the course of some years study of the Northern Rhodesian mammal fauna it has become increasingly apparent how very much more there still is to learn, both in regard to taxonomy and distribution, to say nothing of ecology, which as yet can hardly be said even to be in its infancy in central Africa. Skead (1955) draws attention to the need for an organised zoological survey in Southern Africa, and understandably deplores the fact that the financing of past collecting expeditions has often had to depend on the generosity of private individuals.

Various mammals keep turning up outside their previously known ranges, while there are undoubtedly others that will, when more material is available, have to be described as new. Among the larger ones, ungulates particularly, there is of course little likelihood today of new species being found but, nevertheless, in most cases we are far from clear as to the precise limits of range of those known, a matter that is complicated by the reductions in both range and numbers that have taken place in recent times, and which in many cases still continue. Already it is becoming difficult to tell where many of the larger ungulates once existed, but have been wiped out, from where they were never known to occur at all.

As far as the variations in these larger mammals are concerned, chronic shortage of comparative material for the most part effectively prevents evaluation of the validity of the named geographical races, many of which were originally described on few or even single specimens.

It is little short of a zoological tragedy that, while so many of the large mammals are annually being killed all over Africa, practically nothing gets preserved for study purposes. This has been pointed out previously, notably by Matthews (1954) and Hill (1942), from which latter the following may be quoted, as it is very apt and to the point:

> The large mammals of Africa have been killed in great numbers by white men for more than a hundred years, but, while the species are for the most part adequately characterized, few of the geographical races have been substantially established. Large size makes transportation, storage, handling and comparing specimens difficult and expensive. All the scientific collections combined often do not have adequate numbers of these animals to distinguish individual variation from geographic.

This is undoubtedly so and, apart from the wonderful Rainey and Roosevelt collections from East Africa, written up by Hollister (1924), and the Verney-Lang specimens from the Kalahari expedition, described by Hill (1942), there can be few, if any, other cases where really good series of African ungulates have been properly collected and preserved with full scientific data. (I am not, however, aware of the extent to which the larger mammals may have been collected in central Africa in recent years by the expeditions generously sponsored and led by Mr. Bernard Carp.)

Concerning the smaller forms, while the numbers of specimens available are usually incomparably greater, at the same time more variations occur than in the larger and more widely ranging species, though the nature of such variations is often improperly understood, and many genera are in a very confused state and badly need revision. A material factor here is that both the private collector and the zoological expedition usually operate over a comparatively small area, and in the case of the latter, often for only a limited period. Consequently several areas and some seasons get left out, not infrequently just where intergrading might be expected. Also the characters ascribed to various races originally erected on inadequate material are frequently found not to hold good where long series are assembled.

In their important work of reclassification, Ellerman *et al.* (1953) have made their approach on the basis of a very broad concept of species, similar to that of Ellerman and Morrison-Scott (1951). But in spite of the disclaimer on page 1 of the latter work, that lumping had not been indulged in to a greater extent than the evidence justified, there is little doubt that the adoption of a similar method in "Southern African Mammals" has caused them in many cases to do just that.

The general principle of conspecificity in relation to geographical replacement would, one imagines, not be widely questioned today. All workers on African mammals realize the number of forms long standing as species which must really be subspecies. But, all the same, the lumping in the work under reference seems often to have gone rather too far; not only beyond, but in at least one instance contrary to the evidence afforded by the specimens themselves. For example, only two species of *Steatomys* are admitted in Southern Africa, whereas in at least one part of Northern Rhodesia, and probably elsewhere, there are three quite distinct ones that occur in the same place (none of which, incidentally, is *S. bocagei*, the only other species allowed by Ellerman *et al.* in addition to *S. pratensis*.) I hope to go more fully into this particular matter when additional material is to hand, but mention of it here will suffice to illustrate my point.

The method of the late Dr. Roberts, on the other hand, was one of very fine analysis, resulting in the oversplitting of many species (Roberts, 1951). It must be remembered, however, that Roberts was unquestionably a very competent field naturalist and his observations on variations in their relationship to ecological factors, climate, and so on, were very sound and well worth consideration.

This part of his work has most unfortunately tended to become obscured by his inclination toward extreme splitting.

A further matter that requires notice in "Southern African Mammals" is the inclination expressed toward discontinuing the trinomial system of nomenclature, though the authors do not actually go so far as to carry this out. No doubt, as they point out, this would come as a shock to the orthodox—but not for the reason implied. The shock (perhaps "surprise" would be a more accurate term) lies in the fact that, while it is proposed to abolish subspecies, no substitute is suggested to replace that useful category. One must naturally acknowledge the validity of the criticism that the trinomial appears to put a finite label on to something that is not really so; but does not the very fact that this is recognized go a good deal of the way toward answering the objection? Provided it is regarded for what it really is, and not considered more than a convenient manner of designating variations within a species (i.e., literally "sub-specific"), the use of the trinomial is surely more useful than harmful.

In nature, variations within species undoubtedly occur and must merit consideration. To account for them by ignoring them is not to account for them at all.

The point of view in respect of dropping the trinomial has been developed somewhat more fully by Morrison-Scott (1952) though in connection with British rather than African mammals. It may be admitted that it is not always possible to assign a subspecific name to each and every specimen; and that in any population there will often be some specimens individually indistinguishable from those of another related population. Indeed, no one who has ever had to do with long series of specimens from different, though adjacent, areas would question it. But is this any real argument for dropping the trinomial where it can be usefully and properly employed? I think not.

One agrees, of course, that the species is the thing that really matters, and that subspecies are a matter for the specialist; but this is surely a far cry from leaving them out of consideration altogether. To pass over subspecific differences as trivial seems very much like question-begging and, as I have said, minor variations are not adequately dealt with simply by treating them as if they did not exist.

The same considerations apply *a fortiori* to the study of African mammals where, to repeat Meester, we are still very much in the exploration stage. I am not against the broad concept of a species—on the contrary I am very much inclined to such a view—but I do feel there is need for some conservatism at present with so many gaps in the material, and that lumping should not be prematurely extended beyond the available data.

Ultimately, I believe the cline will have to be invoked in order to express subspecific variations properly, or perhaps better still the amplification of it proposed by Lundholm—the "cline complex" (Lundholm, 1955*b*). But to work out a cline complex accurately would, for most species, involve collection and study of a great deal more material than hitherto available—certainly I know of no

exception to this in the Northern Rhodesian mammals. Special care would have to be taken to get specimens from the many areas not previously collected over —an enormous task and one which I am afraid I cannot see being carried out extensively in the near future.

It is true that Ellerman *et al.* make a passing reference to clines, but they do not expand the theme, nor appear definitely to suggest it in replacement of the subspecies they would drop. In any event, Huxley (1938) proposed the cline as an auxiliary principle, clearly pointing out that it was intended to supplement, and not to replace, established taxonomic practice. Neither did he recommend the discontinuation of the trinomial but, on the contrary, elsewhere has adduced (1940) good reasons for its retention and, even further, suggested that a quadrinomial nomenclature should normally be recognized as an ideal, i.e., names of the genus, subgenus (or other analagous category such as "species group"), species and subspecies.

It appears that even in expressing subspecific variation in terms of a cline (or cline complex) the trinomial would still be required to indicate more or less definite stages in the character gradations concerned, as for instance Lundholm (1955*a*) uses it to indicate the northern extreme of a cline in *Pronolagus crassicaudatus*. It may be observed that while Lundholm's cline complex offers a very satisfactory way of demonstrating variations within a polytypic species, the manner of its expression could perhaps be bettered. A cline complex being, by definition, a way of expressing how different character gradations run in different directions, it seems rather inadequate to designate it merely by nominating the geographically most distant subspecies. That seems to be the manner of illustrating a cline, not a cline complex, which would appear to require, for the sake of completeness, indication of all the known character grades susceptible to this mode of treatment. One may illustrate the point by a hypothetical example, in which the species concerned is *X*. Suppose there is a graduation from east to west in darkening of the pelage, represented by named subspecies *A* and *B* at each end of the cline; while proportionate tail length, let us say, varies from south to north, being represented in the extremes by the forms *Y* and *Z*. There might be few or many intermediate named races in between. I suggest, in such a case, that the position could best be shown in some such manner as "Species *X*; cline complex *A–B/Y–Z*." Then, and only then, could the subspecific names for the intermediates (where not obviously synonyms) be dropped without loss of accuracy.

Where a cline, or cline complex, is not demonstrable, as may be the case with some species, there appears no satisfactory alternative to trinomials if we are to take variation within the species into account and not ignore it.

For instance, the color variability in different populations of the small Northern Rhodesian molerats (*Cryptomys hottentotus* subsp.) which I am at present investigating leads me to believe that, while there is extreme differentiation in the white markings, it is doubtful if this can be correlated directly with geographical distribution—it does not, that is to say, represent a "geocline."

These differences in the usually quite isolated populations of small molerats are not great, but are apt to be very constant indeed, and I am inclined to think they could best be regarded not so much as subspecies proper as "microsubspecies" which, though not according to Huxley (1940) requiring incorporation into the formal nomenclature, might nevertheless receive some sort of distinguishing appelation, if only in such form as "Series *A*, *B*" and so on.

In the lechwe, *Kobus* (*Hydrotragus*) *leche*, while a good deal more material remains to be collected and examined before any definite conclusions can be reached, indications are that while there is a color cline running from the west and southwest to the northeast, the horn size in males does not coincide with this, the largest heads on the average being found on the Kafue flats, in the middle of the range of the species. If additional material eventually confirms this, then a cline complex should be worked out to represent the position concisely and accurately.

It may be objected that the idea of the cline complex is likely to prove complicated where several different character gradations may be involved. Certainly it would require a good deal of additional collecting and much painstaking study, but one can only say that such matters can hardly be tackled properly by oversimplification. I am convinced that work on the lines suggested would, in time, lead to the building up of a much truer and more complete picture than can be achieved either by extensive lumping or very fine splitting.

LITERATURE CITED

Ellerman, J. R., and T. C. S. Morrison-Scott. 1951. Checklist of Palaearctic and Indian mammals. Brit. Mus. (Nat. Hist.), London, 810 pp.

Ellerman, J. R., T. C. S. Morrison-Scott, and R. W. Hayman. 1953. Southern African mammals. Brit. Mus. (Nat. Hist.), London, 363 pp.

Hill, J. E. 1942. Results of the Vernay-Lang Kalahari Expedition. Larger mammals of the Bechuanaland Protectorate. Bull. Amer. Mus. Nat. Hist., 79 (5): 371.

Hollister, N. 1924. East African mammals in the U.S. National Museum. Bull. U.S.N.M., 99, Part III: 1–151.

Huxley, J. S. 1938. Clines: an auxiliary taxonomic principle. Nature, No. 3587: 219–220.

Huxley, J. S. 1940. Towards the new systematics. Chap. 1, *in* The New Systematics. Clarendon Press, Oxford.

Lundholm, B. G. 1955*a*. Descriptions of new mammals. Ann. Trans. Mus., 22 (3): 293–294.

Lundholm, B. G. 1955*b*. A taxonomic study of *Cynictis penicillata* (G. Cuvier). Ann. Trans. Mus., 22 (3): 319.

Matthews, L. H. 1954. Research on the mammals of Africa. Nature, 174: 670–671.

Meester, J. 1954. Research on the mammals of South Africa. Nature, 174: 1149.

Morrison-Scott, T. C. S. 1952. A list of British mammals. Brit. Mus. (Nat. Hist.), London, pp. 4–5.

Roberts, A. 1951. The mammals of South Africa. Central News Agency, Johannesburg, 700 pp.

Skead, C. J. 1955. The need for a zoological survey in South Africa. S. Afr. Mus. Assoc. Bull., 6 (4): 101–103.

Game & Tsetse Control Dept., Ndola, Northern Rhodesia. Received May 17, 1957.

GENERAL NOTES

CONCERNING PLATYPUSES

For the past ten years the only living duck-billed platypuses, *Ornithorhynchus anatinus*, outside their native Australia and Tasmania were the two in the collection of the New York Zoological Society. These two (male and female), together with a third which died of pneumonia in 1948, were procured by David Fleay of the Badger Creek Sanctuary, Victoria. They reached New York on April 26, 1947, at which time they were estimated to be about 16 months of age. Elaborate quarters were prepared providing a shallow tank for swimming and feeding, a dry retreat, and a bank for burrowing in case of attempted nest-building. The two were usually housed separately and during the summer, when they were outdoors, each was on display for a few hours daily. Over half a million visitors viewed them during this time.

The platypus has been called "a kind of link between mammals and the later mammal-like reptiles of Triassic age" (W. K. Gregory, Bull Amer. Mus. Nat. Hist., 88 (1): 7, 1947). In many respects it still remains an enigma. The bill is a soft, leathery organ with two nostrils dorsally. Although teeth are present in the embryo, they are lost before hatching; in adults, serrations on the margins of the bill serve for capturing and crushing food. The heavy tail is flattened, beaver fashion. The skeleton contains an interclavicle and paired epipubic bones in both sexes. Each foot is broadly webbed and equipped with five claws. The purpose of the poison spur on the hind foot of the male is not well known. The senses of sight and hearing are keen in air, but when submerged the eyes and ears are closed by a fold of fur and the animal relies largely on touch, probing with its sensitive bill. The voice is a low growl, seldom heard.

In their native homes platypuses breed in the spring (September to December). An intricate courtship behavior precedes mating. Two weeks later there are laid one to three (usually two) white, leathery-shelled eggs about ¾ inch long, in the leaf-lined nest of a streamside bank burrow. The platypus has once successfully mated in captivity, and one baby was reared (Fleay: We Breed the Platypus; Robertson & Mullens, Melbourne, 1944). After an "incubation" period of about 7 to 10 days the young hatch, aided by an "egg tooth" on the upper jaw which is soon shed. They measure about one inch in length and are quite naked. They are nourished on milk which oozes into the soft fur from the "mammary" glands, lacking nipples, which are scattered over the abdomen. Development is fairly rapid; they are weaned by about four months, at which time they first emerge from their burrow, usually in February; they are over a foot in length and able to move about actively.

Hopes were high, in 1953 and 1954, of their breeding in captivity at New York. In May the female evinced more than her usual interest in the male, scratching at the door and attempting to gain entrance to his quarters. The two were allowed in the tank together daily after this. The odd prenuptial behavior, as described by R. M. McClung (Animal Kingdom, 62: 110–111, 1954), consisted of the male's grasping the female's tail firmly in his beak, the two then swimming slowly in circles. This action was combined with frequent nuzzling of each other's back and tail, and accompanied by a maneuver in which the female rolled over and over in the water, as though trying to loosen the male's grip on her tail. When successful, however, she usually returned to him! After about an hour both animals tired of this activity and seemed more interested in food. This courtship continued until June 10. Mating was not observed but was supposed to have taken place about this time. The female's interest in the male abated after June 14; she developed a voracious appetite (almost doubling her daily food intake for a few weeks), gained weight, and went into seclusion in her newly constructed bank burrow on June 21. Eucalyptus leaves, provided for nest-building, disappeared from the pool. But all this was a false alarm, for excavation of the burrow system on November 5 revealed no nest, no eggs, no young. The conditions of captivity, lack of privacy from human observers, disturbance of the normal nocturnal habits, or reversal of the seasons may be factors preventing breeding in the Northern Hemisphere.

The male was normally about twice as heavy as the female. Typical of their weights as adults were the following: October 29, 1955, after a summer outdoors, male 3.83, female 1.85 lb.; May 11, 1956, after a winter indoors, male 3.13, female 1.61 lb. Amounts of food consumed seem tremendous for animals of this size—a daily ration of about half the animal's own weight. A sample daily quota for the male (then 3.3 lb.) included 1 lb. of earthworms, 20–30 crayfish, 200 mealworms, 2 small frogs and 2 coddled eggs. The female ate proportionately, but prior to her supposed egg-laying her diet increased to 50 crayfish and 4 eggs. Their appetites and food preferences varied considerably throughout the year. In the wild their diet includes snails, aquatic insets, or even small fish that are probed from the mud and may be stored in the internal cheek pouches.

Longevity of these two specimens, still alive at the time, was reported (Jour. Mamm., 38: 279, 1957) as 9 years and 9 months. In Australia, Fleay has maintained one for more than 10 years. Another escaped after a number of years in captivity; six weeks later a platypus, apparently the same individual, was captured and remained alive for several years longer—a life span of nearly 14 years, if this was the same individual, as seems likely. The captive female at New York also escaped, on July 26, 1957; despite much publicity and diligent searching, day and night for three weeks, she was never located and was "presumed dead" with the coming of cold weather in October. The male remained in his customary quarters. Then, by August 13, his appetite waned, he lost weight, and finally he died on September 18, a mere 2.31 lb. Autopsy revealed no degenerative condition or indication of disease or injury as the cause of death. His established age (excluding infancy prior to capture) was 10 years, 4 months and 24 days and his probable age closer to 12 years.—RICHARD H. MANVILLE, *U.S. Fish and Wildlife Service, Washington 25, D.C.* *Received October 20, 1957.*

NOTES ON A CAPTIVE MOLE

On July 5, 1957, a live prairie mole, *Scalopus aquaticus*, was captured near Hickory Corners, Michigan, while it was attempting to cross a road. When I received the mole it had been without food or water for 24 hours. Its weight, after eating, was 68.5 grams. When the mole was released on August 14, 1957, it weighed 75.5 grams.

Throughout most of its period of captivity the mole was kept in a cage containing only an inch of soil so that it could be easily observed. The soil was frequently cleaned and kept in a moistened condition. The mole ate earthworms, dead birds, walnuts, crackers, and cheese. It sometimes steadied food with its forepaws but was clumsy at this. Earthworms were munched from end to end like spaghetti. Unlike its relative, the shrew, the mole lapped water from a dish like a dog, keeping its snout in the water throughout.

After each cleaning of its cage, the mole attempted to dig, putting its nose to the floor and moving about the cage trying to cover itself with soil. After becoming accustomed to the strange surroundings, however, it ran about above ground, supporting itself on the sides of the front feet with the palmar surfaces outwards. When given soil in which to dig, the mole immediately pushed itself beneath the soil with lateral strokes of its powerful front feet. It constructed permanent tunnels by rotating its head and foreparts nearly 90° to pack the top of the tunnel with one of its forefeet.

The mole showed no response to light and only occasionally responded to loud sounds. It reacted to vibration, however, by freezing, sometimes remaining motionless for several minutes. Most of the day was spent curled in a cage corner in a restless sort of sleep. The mole frequently awoke long enough to clean itself with rapid motions of its hind feet. In the evening it was very active, spending most of its time clawing at the screen side with its front feet. The little animal seemed to enjoy and need exercise and was always very active while awake. It was usually silent but sometimes made a barely audible twitter when eating a worm or when disturbed.

The mole showed no inclination to kill a half-grown *Peromyscus leucopus*, one-tenth its size, which was placed with it. On the contrary, the tiny mouse completely dominated the larger

animal, showing no fear of it whatsoever. When the two met the mouse gave a little squeak and jumped at the mole, causing the latter to beat a hasty retreat. Sometimes the mouse chased the mole and gave it a nip or two. This behavior continued for several days until the mouse was able to escape through a hole which the mole clawed in the screen.—JOHN P. ROOD, *1615 Dover Rd., Kalamazoo, Michigan.* *Received August 17, 1957.*

RESPONSES OF AFRICAN MONKEYS TO NATIVE STRATAGEMS

During a recent expedition to Africa to collect specimens of different monkey groups, I secured the services of a very able African hunter at Epulu (formerly Camp Putnam) in the Belgian Congo. This man was at times able to find the general location of monkey bands by giving a loud series of honking cries. On one occasion I heard a monkey respond with the same cry, and the native hunters were able to hear other responses that were beyond the capacity of my rather poor hearing.

When the hunter who gave the calls was able to approach bands of monkeys in the heavy forest without being detected, himself unable to see the monkeys, he went through a remarkable procedure. Moving with great caution into the area under the estimated position of the monkeys, he grasped a double handful of underbrush and rustled it as loudly as possible while making a loud hissing sound with his mouth. Instead of fleeing or hiding and remaining silent, the usual responses to disturbances from the ground, the monkeys immediately responded with repeated loud, chattering cries different from any I had heard before. The hunter was then able to move about under the trees until he could locate the animals by sight and shoot them. The cries from the monkeys continued even after the first shot, and it was only after several shots that the survivors fled.

According to the native interpreter, the monkeys thought one of their number was in trouble on the ground, and they were signaling to him. The one time I was able actually to see monkeys exhibiting this behavior may give support to this interpretation. I observed several members of a band (*Cercocebus albigena johnstoni*) looking down at the ground while uttering this cry, moving about nervously in the trees, then stopping to utter the cry again, concentrating their attention downward all the time.

I was unable to detect any difference in this cry for *Cercocebus albigena johnstoni* and *Cercopithecus mona denti*, the only two species collected in my immediate presence. In view of the considerable differences in other calls between these representatives of quite distinct genera, this great similarity is rather surprising.—N. C. TAPPEN, *Dept. of Anatomy, Emory University, Georgia.* *Received September 6, 1957.*

DOES *PYGODERMA* OCCUR IN NORTH AMERICA?

The phyllostomatid bat genus *Pygoderma* has frequently appeared in check lists of North and Middle American mammals. Thus Miller and Kellogg (1955) give as the range of *Pygoderma bilabiatum* "southern Brazil to southern Mexico." Unable to find any recent Mexican or Central American records, I tried to find the earliest mention of the species occurring in Mexico.

The species was first described by Wagner (1843) from Brazil as *Phyllostoma bilabiatum*. It was redescribed by Gray (1848), also from Brazil, as *Arctibeus leucomus*. Peters (1864) described *Stenoderma* (*Pygoderma*) *microdon* from Surinam as a new subgenus and species. This is the earliest mention of a member of the genus outside Brazil. The only reference to Mexico in the paper is in a footnote. On page 83, in the course of describing *S.* (*P.*) *microdon*, Peters wrote, "Die beiden oberen Praemolares sind ähnlich wie bei *Dermanura* (*cinereum* Gervais[1]). . . ." The footnote referred to reads, "Das bisher unbekannte Vaterland dieser Art ist Mexico, woher wenigstens das exemplar unseres Museums stammt." It is evident that the footnote refers to a specimen of *Dermanura cinereum* (=*Artibeus cinereus*) from Mexico, not to *Pygoderma*. The former species is well known from Mexico. Two years later, Peters (1866)

raised *Pygoderma* to full generic rank and recognized that his *microdon* was the same as Wagner's *bilabiatum*. Thus he lists *Pygoderma bilabiatum* with *leucomus* and *microdon* as synonyms without comment. There have been no real taxonomic changes since then.

The first reference to *Pygoderma* in Mexico is by Dobson (1878), who gave the range as "Brazil, Mexico." He mentioned no Mexican specimens and it seems almost certain that he misread Peters' description and thought that the above-mentioned footnote referred to a Mexican specimen of *Pygoderma*. Various later writers appear to have merely copied Dobson. There is, incidentally, no mention of *Pygoderma* in Alston (1879–1882). The only other record outside Brazil is that of Thomas (1901) from Paraguay.

It therefore appears that *Pygoderma* is restricted to eastern tropical South America from the Guianas to Paraguay. There is no reason to believe that it occurs anywhere in Middle America or even western South America. *Centurio* appears to be the only genus of specialized short-faced stenodermines in Middle America. The only other stenodermine genera in Mexico are *Uroderma, Vampyrops, Chiroderma, Enchisthenes* and *Artibeus*.—Karl F. Koopman.

LITERATURE CITED

Alston, E. R. 1879–1882. Biologia Centrali-Americana. Mammalia. London. 202 pp.

Dobson, G. E. 1878. Catalogue of the Chiroptera. London. 567 pp.

Gray, J. E. 1848. Observations on some Brazilian bats with the description of a new genus. Proc. Zool. Soc. London, 1848: 57–58.

Miller, G. S. and R. Kellogg. 1955. List of North American Recent mammals. U.S. Natl. Mus., Bull. 205: 1–954.

Peters, W. 1864. Hr. W. Peters gab Nachricht von einem neuen frugivoren Flederthiere, *Stenoderma* (*Pygoderma*) *microdon* aus Surinam. Monatsberichte Akad. Berlin, 1863: 83–85.

———. 1866. Hr. W. Peters las über Flederthiere *Vespertilio soricinus* Pallas, *Choeronycteris* Lichtenst., *Rhinophylla pumilio* nov. gen., *Artibeus fallax* nov. sp., *A. concolor* nov. sp., *Dermanura quadrivittatum* nov. sp., *Nycteris grandis* nov. sp. Monatsberichte Akad. Berlin, 1865: 351–359.

Thomas, O. 1901. On a collection of bats from Paraguay. Ann. Mag. Nat. Hist., ser. 7, 8: 435–443.

Wagner, A. 1843. Diagnosen neuer Arten brasilischer Handflügler. Wiegmann's Archiv fur Naturgeschichte, Jahrgang 9, 1: 365–368.

Dept. of Biology, Queens College, Flushing, New York. *Received September 10, 1957.*

WINTER RECORDS OF BATS IN ALASKA

There seem to be no published records concerning the occurrence of bats in Alaska during the winter months. Dufresne (Alaska's Animals and Fishes, 2d ed., 1955) stated that *Myotis lucifugus*, the only bat he lists for the Territory, "is presumed to be present in Alaska only as a summer migrant."

On November 12, 1956, Mossman saw a small bat flying near the hatchery and laboratory of the Alaska Department of Fish and Game Research Station located at Kitoi Bay on Afognak Island. It was probably a *Myotis*, but an attempt to collect it was unsuccessful. Two days previously the temperature went down to 6°F. above zero and the ground was deeply covered with snow from many storms.

Clark, on March 31, 1954, observed a small bat, probably *Myotis*, at "Elk Bay" on Tonki Cape of Afognak Island. While this bat might have been a migrant, it was certainly an early one, phenologically speaking, since there were still snow banks near the beach in sheltered locations.

In view of these observations, it seems possible that some *Myotis* may overwinter in Alaska. —Archie S. Mossman, *Univ. of Wyoming, Laramie,* and W. Kim Clark, *U.S. Fish and Wildlife Service, Kodiak, Alaska.* *Received August 14, 1957.*

SUMMER RECORDS OF *MYOTIS SODALIS* IN INDIANA

Although the breeding range of *Myotis sodalis* remains a mystery, bat collecting in Indiana during the past decade has shed some light on its summer distribution. Lyon (1936) recorded the species from only Crawford (Wyandotte Cave, the type locality), Greene and Knox counties. Some of these were June and August specimens, but no mention was made of this fact. This may have been because *sodalis* was then so little known, having been described a short time previously by Miller and Allen (1928). Kirkpatrick and Conaway (1948) published a record of a female (Purdue Wildlife Laboratory Coll. 366) taken May 13, 1947, at Lafayette, Tippecanoe County. We have examined recent specimens from Clay, Kosciusko, Lawrence, Monroe, Montgomery, Parke, Steuben, Tippecanoe, Washington and Wayne counties. With the exception of the Lawrence and Monroe county records (which are for the wintering period) these additional localities from which *sodalis* has been taken are of considerable interest. Due to the paucity of published records for *sodalis* in summer, we have included all of the Indiana data below.

Richard E. Phillips shot a female (U.S. Nat. Mus. 296,429) at Lafayette on April 26, 1952. Mumford collected the following under a large cement bridge at Turkey Run State Park, Parke County: a male (P.W.L. 765) August 16, 1948; two males (W. Gene Frum., 1,913; Chicago Nat. Hist. Mus., 74,045) July 1, 1952; one immature male (C.N.H.M. 74,048) July 24, 1952. This latter specimen, which was probably barely, if at all, able to fly, represents the youngest *sodalis* we have seen. There are additional records from Turkey Run. Lowell L. Getz examined an individual in May, 1951, that was found beneath the loose bark of an old tree; the bat was released. Nixon Wilson and John Hamm found a cluster of four *Myotis* hanging under the bridge mentioned above on July 27, 1957. They captured three of them (the fourth flying away) and found all to be immature male *sodalis*. Judging from its appearance and behavior, they thought the bat that escaped was an adult *sodalis*. One of the young (N. Wilson, 82) was preserved, while the remaining two were banded and released.

An unsexed specimen (Joseph Moore Museum, 113) was shot by Mumford near Brazil, Clay County, in July, 1949, and he shot a female (U.S.N.M., 297,236) in Washington County, June 30, 1953. Cope collected a male (J.M.M., 750) near Centerville, Wayne County, on May 22, 1954. P. Boring shot a lactating female (J.M.M., 990) at Shock Lake, Kosciusko County, on July 20, 1955. On the evening of July 27, 1957, Laurence C. Binford, Robert Haubrich and Mumford were shooting bats in Steuben County. From 8:30 to 9:00 PM they observed about 20 small, dark bats feeding 15 to 50 feet above the ground at the edge of a small woodlot. Binford shot three of them, all of which were immature *sodalis*. These specimens (R.E.M., 872–874), one female and two males, weighed 6.2, 6.0 and 6.6 grams, respectively. On August 5, 1957, Mumford found about 65 *Myotis* in Ray's Cave, Greene County, and collected from them two immature male *sodalis* (R.E.M., 895, 896) and four *lucifugus*. Cope collected an immature male (J.M.M., 1,118) in a house near Centerville, on August 5, 1957. Nixon Wilson collected an adult male (N.W., 79) in Montgomery County on September 7, 1957. This rounds out the recent records known to us.

Older summer specimens are extant, but have heretofore been given scant consideration. Among bats in the collection of the U.S. National Museum is an adult female (136,455) collected by E. J. Chansler on June 30, 1896, at Bicknell, Knox County. A. N. Caudell took three additional females (141,877–79) at Wyandotte Cave, August 17, 1905.

From the known dates of birth of *Myotis lucifugus* in the state, one would expect parturition in *sodalis* at about the same time—late June. This assumption seems borne out by the collecting of several weak-flying young in late July. There is no doubt in our minds that *sodalis* breeds in Indiana.

Populations of *sodalis* that winter in southern Indiana caves depart in April and return in November, as a rule. Stragglers, however, are found in the fall as early as August. Most of the earliest arrivals to the caves are males. Elsewhere over the range of the species, many of the published summer records have also been for males (Mohr, 1933; Black, 1934, 1936). We

have banded a considerable number of *sodalis* in winter in the caves of southern Indiana, but to date have obtained no clue as to the areas utilized by these animals in the summer. A northward movement is indicated in the spring, for Clay, Kosciusko, Montgomery, Parke, Steuben, Tippecanoe and Wayne counties are all a considerable distance north of any known wintering area in the state. For this reason, the April, May and September records were included in this paper. Extensive bat collecting has not been conducted in northern Indiana; thus the coverage there is simply too thin. We have failed to find *sodalis* in two rather large breeding colonies of *lucifugus* in Jackson and Lawrence counties.—RUSSELL E. MUMFORD AND JAMES B. COPE.

LITERATURE CITED

BLACK, J. D. 1934. *Myotis grisescens* and *Myotis sodalis* in Arkansas. Jour. Mamm., 15: 67–68.

———. 1936. Mammals of northwestern Arkansas. Jour. Mamm., 17: 29–35.

KIRKPATRICK, C. M. AND C. H. CONAWAY. 1948. Some notes on Indiana mammals. Amer. Midl. Nat., 39: 128–136.

LYON, M. W., JR. 1936. Mammals of Indiana. Amer. Midl. Nat., 17: 66–67.

MILLER, G. S., JR. AND G. M. ALLEN. 1928. The American bats of the genera *Myotis* and *Pizonyx*. Bull. U.S. Nat. Mus., No. 144: 130–135.

MOHR, C. E. 1933. Observations on the young of cave-dwelling bats. Jour. Mamm., 14: 49–53.

Univ. of Michigan Museum of Zoology, Ann Arbor, and Joseph Moore Museum, Earlham Coll., Richmond, Indiana. *Received September 30, 1957.*

THE SEMINOLE BAT IN OKLAHOMA

The Seminole bat, *Lasiurus seminolus*, has not been reported from Oklahoma. Sealander (Jour. Mamm., 35: 584, 1954) reported one from southern Arkansas, and quoted Lowery as saying that the species is rare in northern Louisiana.

On August 23, 1954, Claud Ward shot a female Seminole bat on the Little River, 6 miles south of Eagletown, McCurtain County, Oklahoma. The location is only some three miles from the Arkansas State line, and is in the cypress-sweet gum forest association characteristic of the river bottoms to the south and east. Ward and the writer collected extensively in this part of Oklahoma during the summers of 1954, 1955 and 1956. While many red bats, *L. borealis*, were taken, this is the only example of the Seminole bat secured.

Financial support for field work was supplied by the Oklahoma State Department of Health.—BRYAN P. GLASS, *Oklahoma State Univ., Stillwater. Received August 31, 1957.* [Contribution No. 260 from Dept. of Zoology, Oklahoma State Univ.]

FOUR-THUMBED FREE-TAILED BAT

A female *Tadarida brasiliensis mexicana*, having a double thumb on each wing, was collected at Davis Blowout Cave in Blanco County, Texas, on August 21, 1957. This animal was a young of the year, determined by lack of epiphyseal closure.

The double-thumb arrangement of the right wing was easily noted since the claws and two millimeters of the terminal portion of the thumbs were completely separate, the remainder of the thumbs being joined by loose skin to their bases.

On the left wing the bones of the bi-thumb were in close association, but proved to be separate upon dissection. A tight skin covering enclosed the bones their entire length, leaving only the two claws distinct.

This free-tailed bat (1712 in preserved collection) was obtained during studies of the ecological association of *Tadarida brasiliensis mexicana* to rabies. The project is supported by the National Institutes of Health.—CLYDE F. HERREID II, *Division of Vertebrate Ecology, The Johns Hopkins University, Baltimore, Maryland. Received October 9, 1957.*

ADULT BROWN BEARS CLIMB TREES

On July 26, 1956, while counting spawning salmon on Salmon Creek, a tributary of Karluk Lake, Kodiak Island, the writer and two other Fish and Wildlife Service employees were startled to find an adult female brown bear (*Ursus middendorffi*) watching us from a large cottonwood tree. The bear was 10 feet up on the first limb, leaning against the trunk. Twenty feet above her was a young cub of about 80 pounds. The author stopped to photograph the bear and it then came down the trunk headfirst in a threatening rush and into the brush on our side of the stream. When we attempted to cross the stream the bear again charged, this time directly downstream with threatening growls and coughing noises. As we retreated, the bear stopped and returned to the base of the tree, where we lost sight of her. On a subsequent visit to the area, the author investigated the tree and found it to be about 3 feet in diameter and virtually impossible for him to climb because of lack of handholds. The trunk was rubbed and scarred with clawmarks and the main limb at the fork had the outer bark worn and clawed off. It appeared to have been used fairly frequently in the past. This seems to rule out either the possibility that the mother was merely attempting to reach a trapped cub, or that she had been driven there temporarily by a rutting boar.

Also, I must rule out the possibility that the sow was aware of our presence beforehand and was attempting to escape, as we approached from the downwind side and were concealed by the heavy brush, plus the fact of her immediate antagonism when she saw us.

The author would much appreciate replies from others who may have further evidence of adult brown or grizzly bears climbing trees, as this fact has been denied in all literature available to me.—Raymond J. Kramer, *2686 South Court, Palo Alto, California.* *Received September 20, 1957.*

NOTES ON HEMATOLOGY OF MICHIGAN BLACK BEARS

In 1952 the Game Division of the Michigan Department of Conservation initiated a study of the black bear in Michigan. One aspect of the project concerned the physiology of bears during hibernation. In order to follow significant changes in the blood during this period, we

Table 1.—*Hematology of Michigan black bears*

BEAR NO.	DATE	AGE	WT., lbs.	RBC, mill.	WBC	PCV, %	HGB, gm./100 ml.	SUGAR, mg./100 ml.
5481 ♂	8/ 6/56	Juv.	25	6.88	15,550	48.5	14.3	134
5915 ♀	8/ 7/56	Ad.	161	6.77	16,050	47	15.6	98
5969 ♀	8/ 7/56	Ad.	126	8.46	21,500	55	17.5	94
5609 ♂	8/ 8/56	Ad.	221	7.81	18,600	57	18.0	62
5484 ♀	8/ 9/56	Juv.	32	5.52	21,600	44	12.9	94
5483 ♂	8/ 9/56	Juv.	34	5.66	14,650	44	10.2	94
5978 ♀	8/10/56	Ad.	131	7.65	26,700	49	18.3	122
5910 ♀	8/10/56	Juv.	24	5.75	24,750	45.5	15.0	
5986 ♀	8/13/56	Ad.	183	5.33	22,650	46	15.6	96
5983 ♀	8/13/56	Juv.	44	6.97	17,450	57	21.6	98
5991 ♂	8/15/56	Juv.	26	6.95	17,150	45	13.8	80
5996 ♂	8/15/56	Juv.	24	6.91	11,550	48	14.8	76
5918 ♀	8/15/56	Ad.	136	8.39	24,700	59	20.3	80
5994 ♂	8/15/56	Juv.	25	8.60	23,150	49	15.4	92
5943 ♂	8/17/56	Juv.	29	8.88	11,750	48	16.6	
5944 ♂	8/17/56	Ad.	184	7.53	23,350	49	15.2	

felt it necessary to obtain some normal values as a basis for comparison. Consequently, in the summer of 1956 we made hematological studies on 16 animals (Table 1).

The method of trapping the bears has been detailed elsewhere (Trans. N. A. Wildl. Conf., 22: 520–543, 1957). The blood was obtained from the jugular vein within 60 to 90 minutes after the animal had been anesthetized with sodium pentobarbital.

The samples were collected in oxalate vials (4.8 gms. ammonium oxalate and 3.2 gms. potassium oxalate in 1000 ml. HOH; 0.1 ml./1 ml. blood), approximately 10 ml. of blood per sample.

Hemoglobin (direct method) and blood sugar were determined with a Fisher Clinical Electrophotometer using the methods given in the Fisher manual. A Spencer Bright-Line Hemacytometer was used to make cell counts. Packed cell volumes were determined with Wintrobe hematocrit tubes.

We are conducting more detailed examinations of bear hematology and will report them at a later date.—W. G. Youatt and A. W. Erickson, *Game Division, Michigan Dept. of Conservation, Shingleton.* *Received August 16, 1957.*

PAST AND PRESENT DISTRIBUTION OF MARTEN IN NEW YORK

A century ago the marten, *Martes americana americana*, was rather widely distributed in suitable habitats of New York State. These habitats included the "green timber" of white and red spruce and balsam fir, found principally in the Adirondack and Catskill mountains. Occasionally martens move into the rock maple, hemlock and yellow birch zone, but they appear to favor the deep cold swamps and steep mountain slopes above 2000 feet.

DeKay (Zoology of New York: Part 1. Mammalia, 1842) indicated that the marten occurs in the elevated and wooded districts of the northern parts of the state. Coues (Fur-bearing animals: a monograph of North American Mustelidae. Misc. Publ. U.S. Geol. Survey, 1877) recorded four specimens from Essex County but did not remark on their abundance. Merriam (The mammals of the Adirondacks, 1884) regarded the animal as common in the dark evergreen forests of the Adirondacks, stating that hundreds were trapped every winter for their fur. Correspondents and older trappers of the Adirondack counties have told me that the marten was common in the early 1900's. Mearns (Notes on the mammals of the Catskill Mountains, etc. Proc. U.S. Nat. Mus., Vol. 21, No. 1147, 1898) does not list the species from the Catskills, although he was informed that the marten still existed in these mountains. Miller (Preliminary list of the mammals of New York. Bull. N.Y. State Mus., Vol. 6, No. 29, 1899) stated that the marten was confined to the wilder parts of the Adirondacks just before the turn of the century.

The New York State Conservation Department has tabulated the take of game (including furbearers) since 1920. Data on the past season's catch are provided the clerk when one applies for a new license. While these statistics are quite inadequate to provide exact information on the number of animals trapped annually, they are useful in giving trends. The reported take of marten for the years 1920–1935, all from the Adirondack Mountains, are tabulated below:

1920	123	1928	183
1921	186	1929	42
1922	187	1930	153
1923	140	1931	627
1924	199	1932	113
1925	131	1933	86
1926	44	1934	329
1927	78	1935	409

Marten are easily trapped, being without suspicion. Most sets are cubbys made of spruce or balsam boughs, although traps are occasionally placed on a notched pole leaning against a tree. In 1932, a trapper of my acquaintance took five marten on the opening day of the

season and 14 during the season. Success of this sort entails fur prospecting and preparation of suitable cubbys well in advance of the open season. A number of marten are taken in traps set for fox, mink, coon and fisher. Canadian lumberjacks, working in the Adirondack logging camps during the 1920's, took marten without resort to traps. A hole three inches wide was bored into the base of a tree or fallen log with an auger. Horseshoe nails, the ends sharpened, were driven into these holes at an angle and bait placed at the far end of the hole. The marten, attempting to secure the bait, was impaled by the sharpened nail points.

The decline in the marten catch throughout the United States during the early 1930's caused concern to conservationists. In 1936, the chief of the U.S. Biological Survey recommended a five-year closed season on marten in all states, this recommendation being endorsed by the North American Wildlife Conference. New York, with other states, accepted this proposal and closed the season in 1936 not only on marten but on fisher and otter as well. In 1949, an open season was declared on fisher and otter, since fur surveys had shown a decided increase in both of these species. The marten, however, has been provided complete protection in New York since 1936. Evidence from trappers, Conservation Department biologists, and fur surveys by the writer indicated a decline in marten populations during the period from 1937 until about 1946. Marten numbers have subsequently shown an increase. Specific records, both of illegally trapped animals, sight records and positive sign (tracks combined with scats) give some indication of the present distribution of the marten in the Adirondack area (Fig. 1) during the past decade. I have been provided records from forest

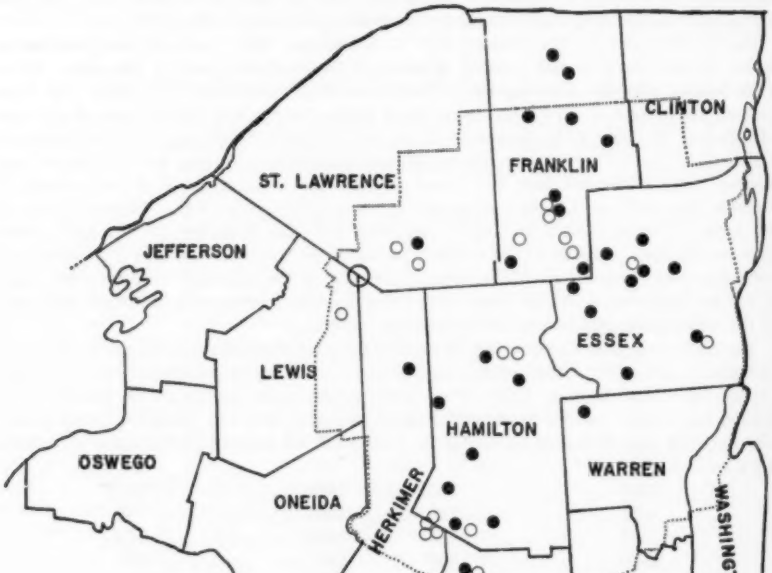

FIG. 1.—Trapped, sight and track records of the marten in New York State (1946 to 1957). The solid dots represent trapped or sight records; clear circles are track records. Broken line is boundary of the Adirondack Park. Highest populations are now found in the Cold River section, the Seward Mountain Range and the higher peaks, all in Essex County.

rangers, fire wardens, game protectors and trusted trappers, some of whom I have known for the past thirty years. A summary of localities where marten have been trapped or seen or where tracks have been observed is listed below:

St. Lawrence Co.: Between Long Lake and Round Lake; south of Cranberry Lake; High Falls on Oswegatchie River; Wanakena; Harrietstown; Santa Clara; Duane; Paul Smith's; a few still persist in Copperbolt area where St. Lawrence, Lewis and Herkimer counties join.

Franklin Co.: St. Regis Pond, south of Paul Smith's; Caulkins Creek area and Duck Hold; Ampersand Mountain; Stoney Creek Mountain; Bridge Brook Pond, Tupper Lake Section; Mt. Morris; St. Regis Lake area; south side of DeBar Mountain; Loon Lake; near Malone.

Essex Co.: Moose Mountain, near Crown Point in isolated spruce and balsam area; southwest of Blue Ridge Mountain; Lake Placid area; Iron Mountain; Newcomb Lake area; north of Newcomb; Lake Colden; Hewitt Pond; Elk Lake; Dix Trail; abundant in Cold River section; Flowed Lands; Marcy Range; Lake Arnold; north of Minerva; Cedar River; Keene Valley; foot of Seward Range.

Hamilton Co.: Redhouse Lake; between Pawley and Hoffmeister; between East Canada Lake and Black Cat Creek; south of Limestone Creek; Hart Valley Lake near Arietta; top of Blue Mountain; 10 miles south of Indian Lake; Honadigua section; Twin Lake section; Silver Lake between Airetta and Stratford; Morehouse Lake; Silver Lake; Cory's; Raquette River; Pigeon Lake, Pigeon Pond and Otter Pond, all south of West Mountain; Blue Ridge Mountain; West Canada Lake.

Lewis Co.: 4 miles north of Belfort. See St. Lawrence Co.

Herkimer Co.: Mud Lake, southwest of Jersey Field Lake; Jersey Field Lake, Salisbury.

Warren Co.: Between North Creek and Thirteenth Lake.

Fulton Co.: Pleasant Lake; 8 miles east of Stratford.

Marten pelts from New York are not of top-notch quality. DeKay (*loc. cit.*) reports pelts selling for $1.25 in the early 1800's. In 1920 the finest pelts have brought $50 to the trapper. In the early 1930's pelts commanded the same price as mink, varying from $10 to $20. Relatively few are intentionally trapped at the present time, most that are caught being taken inadvertently in traps set for other animals.—W. J. Hamilton, Jr., *Cornell University, Ithaca, New York. Received October 16, 1957.*

LONG LIFE OF A RIVER OTTER

On 29 May 1943, on the Wishkah River about 25 miles above its mouth, Grays Harbor County, Washington, G. A. Bushnell met an adult river otter (*Lutra canadensis*) with two young. The adult and one of the young fled. The other stayed and Bushnell was able to capture it. It was a male, estimated age five or six weeks. Bushnell kept the little otter as a pet in his home on the wooded shore of Aberdeen Reservoir. I photographed the otter on 12 December 1945 and Bushnell sent me an account in letter of 3 January 1946: "My wife each day makes about 1½ quarts of bread pudding for our pet. . . . He will eat this much every day. He sleeps in the house; is very friendly and affectionate." The otter roamed freely in and out of the house and was said to capture "grasshoppers, crawfish, periwinkles [caddis-fly larvae], small catfish [cottoids], and occasional trout." He was absent from home from the evening of 2 January to the evening of 10 January 1946. A few days later Mr. Bushnell died, and the otter was sent in February to the Seattle Zoo. Here he died on 27 August 1957 at an estimated age of 14 years and 4 or 5 months.—Victor B. Scheffer, *Fish and Wildlife Service, Seattle, Washington. Received September 21, 1957.*

FOOD HABITS OF WISCONSIN FOXES

In the winters of 1955–56 and 1956–57, data were collected on the food habits of the red fox, *Vulpes fulva,* in south-central Rusk County, Wisconsin. The area studied is about 50 per cent wooded, with dairy farms interspersed on the better soils. The bulk of the

TABLE 1.—*Occurrence of various food items in 29 fox stomachs collected in winter 1955–56 and 1956–57*

PREY ITEM	OCCURRENCE	
	No. stomachs	Per cent
Rabbit, cottontail	18	62
Small mammals	11	38
Carrion	6	21
Muskrats (*Ondatra zibethica*)	3	10
Songbirds	2	7
Chicken (*Gallus gallus*)	1	3
Pheasant (*Phasianus colchicus*)	1	3
Domestic cat	1	3
Unidentified	2	7

wooded area is aspen (*Populus tremuloides*) with some hardwoods on the unburned sites. A total of 25 miles of fox trails were followed on the snow and all kills, attempted kills and visits to old kills were tallied. In addition, 29 stomachs of shot or trapped red fox from the same general area where examined.

The area studied is about at the northern limit in Wisconsin of the range of the cottontail rabbit (*Sylvilagus floridanus*). In this area, cottontails are about one-tenth as numerous as they are in southern Wisconsin, according to hunting-kill indices. The snowshoe hare (*Lepus americanus*), however, is much more abundant than the cottontail due to favorable wooded types. Ruffed grouse (*Bonasa umbellus*) are the most abundant gallinaceous bird, although their populations were generally low during these two years.

Table 1 shows the occurrence of food items in the 29 stomachs. As indicated, cottontail rabbit occurred in 62 per cent of the 29 stomachs. Table 2 shows feeding habits of the fox as indicated by evidence of kills on the 25 miles of trails. The kills of 9 cottontails and 25 small mammals were noted on these 25 miles. Deer and cattle carrion were also utilized.

Arnold (Paper, 17th Midwest Wildl. Conf., 16 pp., 1955) tracked red fox and also examined stomach samples in southern Michigan where cottontails were abundant. He found one cottontail kill for each 18 miles of trails followed, compared to one kill per 3 miles in this study. Richards and Hine (Wisc. Tech. Wildl. Bull. No. 6, 1953), in a study of fox stomachs (primarily red fox) in southwestern Wisconsin, found that cottontails occurred in 45 per cent of 63 stomachs. In view of the low cottontail population in Rusk County,

TABLE 2.—*Fox feeding habits based on 25 miles of fox trails in winter of 1955–56 and 1956–57*

PREY ITEM	NO. OF KILLS	ATTEMPTED KILLS, INDICATED BY TRACKS	RETURN TO OLD KILLS	VISITS TO CARRION
Rabbit, cottontail	9	15	6	
Small mammals	25	35	1	
Squirrels (*Sciurus* sp.)	1	1		
Muskrats	–	1	2	
Deer (*Odocoileus virginianus*)	–	–	–	4
Cattle	–	–	–	3

both our tracking and stomach data show extremely high utilization of this mammal, actually higher than that in the two areas where cottontails are more abundant.

Why the snowshoe hare was not utilized is difficult to explain. Dodds (Jour. Mamm., 36:291, 1955), in a study of red fox food habits in Newfoundland (where cottontails are absent), found the snowshoe hare a major item in the diet. Thus red fox are capable of hunting snowshoe hares. Apparently foxes in this area prefer to hunt cottontails even though this mammal occurs in lower densities than the hare.

The author wishes to acknowledge the assistance of Robert S. Dorney and Robert F. Wendt of the Wisconsin Conservation Department in examining stomach contents.—FAY KARPULEON, *Ladysmith High School, Ladysmith, Wisconsin.* *Received September 14, 1957.*

A NEWBORN PIKED WHALE IN TASMANIA

On June 7, 1957, we examined a small whalebone whale which had been found on the shore at Lewisham in southeastern Tasmania. The animal was much decomposed internally and in the region of the mouth and from its condition we judged it to have been dead at least about a month. Mr. E. C. Clark, who drew our attention to it, said that it had been seen first two weeks before and at that time had the appearance of having been dead for some weeks. We concluded that it had died probably four to six weeks previously and was already dead when it reached the shore at Lewisham.

Its very small size—it was only 7 ft. 1 in. (216 cms.) in straight line length—immediately indicated that it was a fetal or newborn specimen. An inch or two of umbilical cord was still visible, although much decomposed. A detailed examination satisfied us that the animal was a female piked whale or lesser rorqual, *Balaenoptera acutorostrata* Lacépède.

Major external dimensions in centimeters were as follows: snout to posterior edge of ventral grooves, 107; snout to eye, 41; vent to tail notch, 59; vent to navel, 28; length of vent slit, 13; anterior length of flipper, 29; posterior length of flipper, 23; base of dorsal fin, 10; height of dorsal fin, 13; width of tail flukes, 40. The center of the base of the dorsal fin was opposite the anterior end of the vent slit. Both the leading and trailing edges of the fin were curved backward so that the apex pointed rearward and the tail flukes had a well-marked central notch. The mammary slits on either side of the vent were obvious and well developed. The ventral grooves reached back about halfway between the end of the flipper and the navel and counts of the grooves varied between 50 and 60, an exact number being impossible of attainment because of the way in which they bifurcate. The snout, viewed from directly below, was very distinctly triangular in shape. Because of the time which had elapsed since death, it was of course impossible to see the normal coloration, but it was possible to distinguish areas of light or dark pigment. The whole of the underside of the body from chin to tail was distinctly lighter than the back and the underside of the tail flukes in particular looked as if they had been white, or at least very light gray, in life. The outer side of the flipper showed a band of lighter coloring about halfway along its length, which although not very distinct, appeared to be all that was left of the well-known white flipper mark of *acutorostrata*. The skull was poorly calcified and disarticulated easily. There was no sign of fetal teeth nor of baleen.

This appears to be the first definite record of the species for Tasmania. It has been included in previously published lists (Lord and Scott, 1925; Iredale and Troughton, 1934; Pearson, 1936; Scott, 1942) but apparently only because it was presumed to occur and the present record is the first based on an actual specimen. Although Stead (1910) mentioned that the piked whale was once hunted by New South Wales whalers, this seems to be also the first definite published record of a stranding for Australia as a whole.

The occurrence may be of even wider interest, since very little seems to be known about reproduction and movements of this species in the southern hemisphere, where it is not

of commercial importance. It appears to frequent Antarctic coastal waters during the summer months, December to March (Lillie, 1915) and like other balaenopterids probably moves equatorward in winter, when the young are born. The present record suggests births may occur in early winter in the Australian region. It seems doubtful that the Lewisham specimen was full term. Northern hemisphere piked whales appear to be about 9 feet long at birth (Allen, 1916) and Prof. W. Stephenson, who has extensive experience of the species in England, informs us that, provided there is no disparity in size between north and south, in his opinion it could only have been fetal. This suggests that our specimen would normally have been born about June or July. Benham (1901) described a 10-foot piked whale from New Zealand which had partly developed baleen by August 6.—J. L. Davies and E. R. Guiler.

LITERATURE CITED

Allen, G. M. 1916. The whalebone whales of New England. Mem. Boston Soc. Nat. Hist., 8: 107–322.

Benham, W. B. 1901. An account of the external anatomy of a baby rorqual (*Balaenoptera rostrata*). Trans. N. Z. Inst., 34: 151–155.

Iredale, T. and E. Troughton. 1934. A check-list of the mammals recorded from Australia. Mem. Aust. Mus. Sydney, 6: 1–122.

Lillie, D. G. 1915. Cetacea *in* Brit. Antarct. ("Terra Nova") Expd. Nat. Hist. Rep., Zoology, 1: 85–124.

Lord, C. E. and H. H. Scott. 1924. A synopsis of the vertebrate animals of Tasmania. Hobart. 340 pp.

Pearson, J. 1936. The whales and dolphins of Tasmania: Part 1, External characters and habits. Pap. Roy. Soc. Tasm., 1935: 163–192.

Scott, E. O. G. 1942. Records of Tasmanian Cetacea: No. 1, Notes on various strandings at and near Stanley, northwestern Tasmania. Rec. Queen Vict. Mus. Tasm., 1: 27–49.

Stead, D. G. 1910. A brief review of the fisheries of New South Wales. Sydney. 31 pp.

Univ. of Tasmania, Hobart, Tasmania. Received October 5, 1957.

OBSERVATIONS ON A NEWBORN LITTER OF *CITELLUS UNDULATUS*

In 1953 Mayer published a paper (Jour. Mamm., 34: 334–345) with considerable information concerning the arctic ground squirrel, *Citellus parryi barrowensis*. In one section of his article (p. 342) he stated "The only known litter born in captivity was one composed of two females and four males born at Point Barrow, in June, 1950."

Recently, while preparing a manuscript concerning the physiology of the arctic ground squirrel, there was cause to review many of the field notes and data collected at the U.S. Navy's Arctic Research Laboratory at Point Barrow during its early years. In our records there were data referring to a litter which was born in mid-June, 1950. It is my opinion that this is the same litter referred to by Mayer (*op. cit.*).

The colony of ground squirrels at the Arctic Research Laboratory in 1949 and 1950 was made up of specimens collected on (1) the Meade River, (2) Tesheckpuk Lake and (3) Anaktuvak Pass, which according to Rausch (Arctic, 6: 91–148, 1953) might better be called *Citellus undulatus barrowensis* (Merriam). During the summer of 1950 the chief animal keeper was an Eskimo, Pete Savolik, who lived at the Point Barrow Village, and considerable credit should be given to Savolik, Clay Kagilak and Chester Lampey for their role in handling the animals and facilitating adaptation to captivity. According to Savolik, sometime during the middle of May a male squirrel, which occupied a cage on top of that of a female, made a hole through the separating wooden partition. From this time on he was seen to frequently enter the female's cage and a mating occurred. A litter was presented

about mid-June, and it is assumed that the gestation period was about 25 days. It was known that the newborn squirrels were present about June 20, and initially Savolik alone was permitted to handle the young. The mother was not unduly disturbed by him.

It was not until June 27 that we attempted to remove the young in order to record weight changes. At that time, estimated 10 days after birth, three specimens weighed 32.5, 35.4 and 32.9 grams. On June 29, all six specimens were weighed, 46.4, 41.4, 41.8, 28.6, 47.0 and 42.1 grams. At this time it was obvious that the animal which weighed 28.6 grams was a runt.

During the first week in July we were successful in using dye marking and henceforth were able to distinguish individual specimens. Additional weights (in grams) were as follows:

Number	*July 5*	*July 7*	*July 10*	*July 13*
1♂	72.0	79.6	105.2	112.8
2♀	70.9	80.0	96.0	117.0
3♀	50.2	57.4	70.7	79.7
4♂	76.4	80.2	97.8	118.7
5♂	69.9	88.5	99.3	103.3
6♂	75.6	80.2	106.3	109.5

Apart from the weight changes there were other observations of interest. For example, on July 5 the first traces of pelage patterns could be seen and by July 7 the coloration pattern was distinct. On July 10, specimen No. 1 opened its eyes, and following this date they all began to do so.

During the time of observations, the litter nest and the parents were disturbed as little as possible. The animals were handled with cotton work gloves and the mother never seemed to be greatly disturbed at our intrusions. During the following weeks all six animals grew, appeared healthy and became exceedingly active. The father had to be separated from the cage containing mother and young since he became aggressive and consumed too much of the food intended for the young. Eventually even the young became aggressive, particularly with the mother. The young specimens, although very active and excitable, permitted themselves to be petted, fondled and lifted from their cage. Insofar as we knew, upon our departure later in the summer, the animals remained in the effecient and attentive care of Mr. Savolik.—X. J. Musacchia, *Dept. of Biology, St. Louis Univ., St. Louis 4, Missouri. Received September 5, 1957.*

GRAY SQUIRRELS FEEDING ON INSECTS IN CAR RADIATORS

Many instances are known of mammals exploiting unusual food sources. Notes that we have accumulated on the gray squirrel, *Sciurus c. carolinensis*, feeding on insects lodged in automobile radiators provide still another example of such behavior. The observations were made on the campus of the University of Florida, Gainesville, where gray squirrels are particularly numerous.

We first witnessed an individual entering the grill of a car in a parking lot adjacent to the biology building on October 15, 1956. The squirrel had been foraging along a hedge bordering a row of parked cars. It remained inside the grill for a few moments before reappearing and jumping to the ground. It then proceeded to the next car in line, hopped up on the bumper, and attempted to enter the grill, which in this case was too narrow to admit the animal. The squirrel returned to the ground and went beneath the car. There it sat on its hind legs and stretched up toward the radiator, as if seeking a way in from below. It soon moved away and did not inspect any other car while being watched. Although the squirrel was not actually seen to obtain insects on this occasion, there was little doubt as to the reason for its behavior.

Additional observations were made on July 30 and August 8, 1957. On the former date, an individual was watched as it systematically inspected a row of 11 cars. The squirrel examined the grill either by pulling itself up on the bumper, sometimes appearing to be hanging by the fore limbs only, or by hopping up on posts set along the edge of the parking area at bumper height. If the spaces in the grill were large enough the animal entered from the front. When it could not gain entrance to the radiator in this way, it frequently went under the car and climbed up from below. The squirrel did not obtain insects from every car visited. When an insect was secured it was devoured either in the space between the grill and the radiator, on the bumper, or on the ground. Feeding remains examined after the squirrel had departed consisted of the wings of moths, butterflies and grasshoppers.

On August 8 a squirrel was observed for approximately 15 minutes as it searched radiators for insects in the manner described. At one car it made several trips in and out of the grill, during which time it was seen to consume three dragonflies (*Anax junius*) and several smaller insects. The wings and legs were discarded. The smaller insects were usually eaten while the squirrel sat on the bumper or was behind the grill, but the larger ones were carried to the ground and eaten there. In addition to dragonfly remains, wings and legs of ascalaphids (Neuroptera), skippers and the swallowtail butterfly, *Papilio marcellus*, and grasshoppers were found at the site of the squirrel's feeding.

It is evident that more than a single individual in the area engages in this activity. The squirrel observed in October was an adult male with the left foreleg missing, while the individuals, perhaps the same animal each time, seen July 30 and August 8 were adult females.—James N. Layne and Glen E. Woolfenden, *Dept. of Biology, Univ. of Florida, Gainesville.* *Received August 26, 1957.*

RED SQUIRRELS FEEDING AT SAPSUCKER HOLES

At the end of June, 1957, while studying nesting yellow-bellied sapsuckers (*Sphyrapicus v. varius*) in Tamworth, New Hampshire, I had opportunities to watch red squirrels (*Tamiascirus hudsonicus*) feeding at sapsucker holes in gray birches (*Betula populifolia*). The sapsuckers continually revisited a relatively few trees to obtain sap for their young. These trees happened to be predominantly gray birches. Sapsuckers might visit their best trees every 2 to 4 minutes and one pair had two such birches only 15 feet apart. On June 21, a red squirrel ran up to the band of holes on one birch, lapped vigorously, then ran over to feed on the second one, finally returning to lap again on the first tree. Such visits were observed daily for one week. The earliest visit observed was at 5:30 AM, the latest at 8:42 PM. Most visits were in the early morning with a second period of activity late in the day. I never saw the squirrel in the middle portion of a sunny day. However, it appeared at all hours on rainy days. The squirrel lapped continuously when feeding, on one occasion for 27 minutes with only a few short rest periods. In resting, the squirrel always settled in the crotch of an adjacent limb. Here it sat still with forepaws folded over its breast, scratched and licked its fur, or occasionally gave a sputtering song which, as described elsewhere (Kilham, Jour. Mamm., 35: 252–253, 1954), may represent an assertion of territorial rights. The squirrel confined its attention to one birch after the first day. It always lapped on the south side of the tree, at an area which grew to be 8 inches long and 3 inches wide at the bottom, but with a neck an inch wide forming the upper half. The freshly exposed wood had a varnished appearance due to the brownish color of the sap. I did not see the squirrel chew off any bark. It presumably did so, however, for the exposed area differed from the bands of round or usually elliptical to squarish holes made by sapsuckers on the same and other trees. Sapsuckers and hummingbirds (*Archilochus colubris*) fed at the same area as the red squirrel whenever they had an opportunity to do so. There were no conflicts.

On June 26, in another area, I found a pair of sapsuckers with their young feeding on a gray birch by a pond. The birds appeared to be annoyed when a red squirrel drove them from the holes and lapped for 26 minutes. Toward the end of this period, a second red

squirrel joined the first one three different times, only to be driven away on each occasion. Its smaller size suggested that it was a juvenile. When I returned later in the morning, two squirrels were again feding at the same band of sapsucker holes.

Observations of red squirrels taking sap have usually been on sugar maples (*Acer saccharum*) in early spring. As summarized by Hatt (Roosevelt Wild Life Annals, Vol. 2, 1929) red squirrels may take sap at this season as it flows from injured limbs, from sapsucker holes, or from incisions made by the squirrels. The habit is common. Thus at Tamworth, on March 27, 1933, I watched five red squirrels, four on one sugar maple, all lapping sap by crawling along the underside of branches. In June, squirrels and sapsuckers appear to obtain elaborated sap, flowing down from the leaves. Squirrels described above were presumably not just quenching thirst, for one gray birch leaned over a pond and the other was visited throughout several rainy days. In conclusion, sapsuckers make holes which provide sap for a swarm of commensals ranging from butterflies and hornets to red squirrels and a variety of birds as elsewhere described. (Kilham, Wilson Bull., 65: 198, 1953).—LAWRENCE KILHAM, *7815 Aberdeen Road, Bethesda, Maryland.* *Received August 10, 1957.*

REPRODUCTION BY *DIPODOMYS MERRIAMI* IN CAPTIVITY

Reproduction by captive *Dipodomys* has been so rare that each instance is still worthy of note. Eleven or more litters of *Dipodomys ordi pallidus* have been obtained in the laboratory of the Ecological Research Unit, University of Utah (Day *et al.*, Science, 124: 485–86, 1956), and Bailey (N. Amer. Fauna No. 53: 254, 1931) reared one litter of *D. spectabilis spectabilis*. The present note is the third record of reproduction by captive *Dipodomys*, and the first for *D. merriami merriami*.

Individuals of *D. merriami merriami* have been kept under general observation in the laboratory, in connection with a field study. In the field, reproductively active females weigh around 44 grams; females in the last days of pregnancy weigh 46–48 grams. In the laboratory, females that showed typical cycles of external changes weighed an average of 37.8 grams (34.3–45.9 gm.), but the only individual that successfully mated maintained an average weight of 45.9 grams, prior to and after pregnancy. No external changes, or only atypical changes, were shown by captive females weighing less than 34 grams.

A typical cycle of external changes consists of: (1) considerable swelling and protrusion of the vulvar region, often accompanied by a bloody mucous discharge; (2) wide opening of the vulva; (3) rapid regression and tight closure of the vulva. Sometimes a durable mucous plug formed and persisted 18 days or more, but usually only a crust of mucous formed over the vulva. In the laboratory, the open condition of the vulva persisted an average of 6 (3–11) days, and cycles of changes recurred on an average of every 25 (13–45) days. In the longer intervals between vulvar changes some females became imperforate.

Females with open, swollen vulvas were paired with sexually active males. Pairs were placed in indoor cages, 24 × 18 × 12 in., with two interconnected compartments; in outdoor cages 10 × 16 × 11 in.; and in an outdoor cage 8 × 8 × 3 ft. Cage floors were deeply covered with desert sand, and brown-glass bottles or wooden "burrows" were provided as shelters. The successful mating occurred in a small outdoor cage. There were no instances of severe or sustained antagonism between paired rats; the same shelter was often shared although unoccupied ones were available.

One mating in twelve was successful. This was by a female that had consistently maintained a robust weight (45.9 gram average) and showed an uninterrupted sequence of vulvar changes from October, 1956 through July, 1957. Impregnation occurred in the second week of July, when the wild population from which the laboratory stock was trapped was sexually inactive. A litter of three was born on July 31, after a gestation of 17 to 23 days, and has been successfully reared through the age of three weeks.

Initially *merriami* were fed on pearled barley, sunflower seed and lettuce, a ration used for maintenance of *Dipodomys* by some previous workers. However, the one successful mating occurred after the ration had been changed to one composed of: 26% rolled oats, 26% rolled barley, 20% meat meal, 10% dry powdered milk, 11% whole wheat kernels, 2% cod liver oil, 2% sunflower seeds, 2% mixed bird seed, 0.5% iodized salt and 0.5% powdered calcium carbonate, plus lettuce *ad libitum*. This ration is modified from that used by Dice (The Care and Management of Laboratory Animals, Williams and Wilkins Co., Baltimore, p. 174, 1947) for *Peromyscus*. Use of this ration coincided with an improvement in body weight by many of the captive animals.

Successful laboratory mating of *Dipodomys merriami merriami* apparently depends on selective use of those females which, by some inherent vigor or tolerance of captivity, can maintain a weight normal for wild individuals. Size of caging may not be important. Daily fluctuations of temperature, as obtained with outdoor caging, may be necessary if indoor temperatures are too stable.—Robert M. Chew, *Dept. of Biology, Univ. of Southern California, Los Angeles 7.* *Received August 20, 1957.*

THE BACULUM OF THE *PEROMYSCUS TRUEI* SPECIES GROUP

Several subgenera of *Peromyscus* are easily distinguished from each other by their characteristic types of bacula (Blair, Jour. Mamm., 23: 196–204, 1942), but differences have not been found with this character between certain species or even species groups of this genus. Although Sprague (Trans. Kans. Acad. Sci., 42: 495–497, 1939) readily separated species of the *P. leucopus* and *P. maniculatus* groups on the length of this structure, Blair (*op. cit.*) could not separate bacula of the *P. boylei* and *P. truei* species groups. Likewise the species *P. boylei* and *P. pectoralis* of the *P. boylei* species group were not distinguishable by Clark (Ph.D. dissertation, Univ. Texas, 1952) with this character. His examination of the cartilaginous processes of these two species, however, did reveal indicative characters not observed previously. The cartilage tip of the baculum of *Peromyscus* had not been reported in the literature prior to his work, and a preliminary examination disclosed its presence in the *P. truei* group.

The bacula were prepared from fresh specimens in the manner suggested by Friley (Jour. Mamm., 28: 395–397, 1947) and Clark (*op. cit.*). The bone and sheathing tissue were stored in 70 per cent ethyl alcohol until needed and then placed in vials of 2N potassium hydroxide. After 30 minutes a baculum was placed in a petri dish containing water. Under a binocular microscope the fleshy sheathing tissue was carefully opened with a dissecting needle and the baculum withdrawn with forceps. Extra care was necessary when the tissue from the apical end was removed, for the small cartilaginous process was easily detached.

Thirty-one bacula of the species *P. comanche, nasutus* and *truei* were compared and no structural distinctions could be made. In this species complex the structure is a slender bony rod with the proximal end swollen and enlarged (Fig. 1). Although it is commonly curved

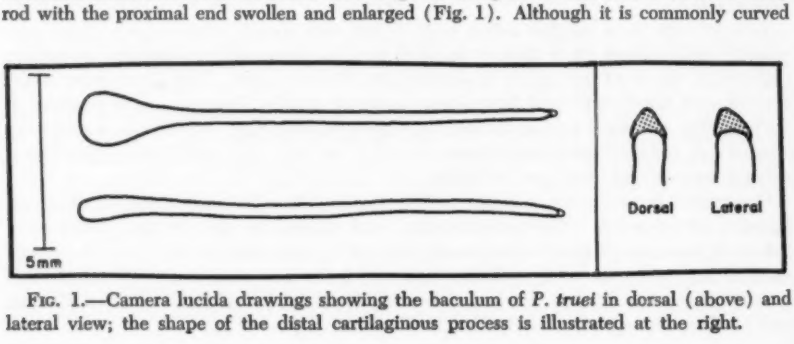

Fig. 1.—Camera lucida drawings showing the baculum of *P. truei* in dorsal (above) and lateral view; the shape of the distal cartilaginous process is illustrated at the right.

dorso-ventrally, the degree and relative length of the curvature varied greatly in individuals of these three species.

A noticable age variation was apparent in these bacula. Young individuals possessed bacula characterized by shorter shafts and less bulbous bases. In older individuals the bases were larger and the shafts longer, and the distal end of the bone adjacent to the cartilage was frequently swollen.

The length and basal diameter of the bacula were measured, and the results are given in Table 1. These data show few differences in the size of this structure between the three species. The length in *P. comanche* was slightly less than in *nasutus* or *truei*, but this difference was not significant. Moreover, the three species were very similar when the length of the baculum was compared with the length of the body of the animal.

The distal cartilaginous processes of these forms are very similar to those of *P. pectoralis* as described by Clark (*op. cit.*). The cartilage tips are slightly larger in diameter than the proximal bony portion and are elongate and triangular in shape (Fig. 1). The average length of the cartilages of *comanche* and *truei* specimens was almost identical. Measurements of eight *nasutus* processes averaged slightly larger (Table 1). However, this difference is minor and consequently of little diagnostic value.

TABLE 1.—*Measurements of bacula and cartilaginous processes and ratio of baculum length to body length; measurements are in millimeters*

SPECIES	NO.	LENGTH OF BACULUM	GREATEST BASAL WIDTH OF BACULUM	LENGTH OF CARTILAGE PROCESS	BODY LENGTH OF ANIMAL	LENGTH OF BACULUM /LENGTH OF BODY
P. comanche	13	13.5 11.2–15.2	1.5 1.0–1.7	0.37 0.33–0.40	95 87–102	14.3 12.4–16.1
P. nasutus	8	14.6 13.7–15.5	1.4 1.3–1.6	0.46 0.36–0.55	101 95–106	14.4 13.2–15.6
P. truei	10	14.1 12.8–15.5	1.6 1.5–1.7	0.35 0.31–0.36	99 96–103	14.3 13.2–15.9

When the apical cartilaginous processes of the *truei* group are compared with those of the *boylei* group, they are found to be smaller than in *P. pectoralis* (0.94 mm.) but considerably larger than in *P. boylei* (0.14 mm.). In shape they are intermediate between these two species. The tip is flattened in *P. boylei*, whereas in *P. pectoralis* it is lanceolate. The structural character of the cartilaginous processes of the *truei* and *boylei* groups is distinctive in the species thus far studied and may be diagnostic in separating members of the two groups.

The similarity of the bacula and their cartilages in the species of the *truei* group is not surprising when their sibling status is considered. More pronounced differences in male genitalia may be present, but on the basis of these characters, mechanical isolation due to structural peculiarities of the male is unlikely. This would apply particularly to males of the sympatric species *nasutus* and *truei*.

The writer wishes to thank Dr. W. Frank Blair for review of the manuscript.—J. R. TAMSITT, *Dept. of Zoology, Univ. of Texas, Austin. Received August 17, 1957.*

ANALYSIS OF A PIKA HAY PILE

Relatively few qualitative or quantitative data are available on the vegetation collected and stored by pikas, *Ochotona princeps saxatilis*, in the Rocky Mountains. The following is based upon analysis of a hay pile located near Trail Ridge Road, ¼ mile west of the Rock Cut at an elevation of 12,000 feet, in Rocky Mountain National Park, northern Colorado.

The dried and partially dried vegetation, packed under several adjacent overhanging rocks on a restricted, south-facing talus slope, was collected on August 10, 1956. Filling a bucket, it weighed 14½ ounces and included all of the hay pile except for small bits tucked into inaccessible crannies. Of this amount, 5000 pieces of vegetation, totaling 4 ounces in weight and representative in composition of the contents of the entire pile, were identified as follows:

	Pieces	*Per cent*
Geum rossii (R. Br.) Ser.	3486	69.7
Foliage	(2890)	(57.8)
Flowers	(597)	(11.9)
Artemisia scopulorum Gray	500	10.0
Stems, leaves, fragments, etc., especially of grasses and reeds, undetermined	356	7.1
Trifolium nanum Torr. and *T. dasyphyllum* T. & G.	291	5.8
Castilleja occidentalis Torrey	57	1.1
Erigeron simplex Greene	55	1.1
Trisetum spicatum (L.) Richt.	48	1.0
Arenaria obtusiloba (Rydb.) Fernald	46	0.9
Sibbaldia procumbens L.	38	0.8
Deschampsia caespitosa (L.) Beauv.	36	0.7
Polygonum viviparum L. and *P. bistortoides* Pursh	31	0.6
Festuca brachyphylla Schult	18	0.4
Luzula spicata (L.) DC.	12	0.2
Agrostis variabilis Rydb.	9	0.2
Ranunculus adoneus Gray	9	0.2
Carex sp.	2	0.04
Carex chalciolepis Holm	1	0.02
Erigeron pinnatisectus (Gray) Nels.	1	0.02
Gentiana tenella Rottb.	1	0.02
Lychnis kingii Wats.	1	0.02
Poa rupicola Nash	1	0.02
Silene acaulis L.	1	0.02

TOTAL: 22 identified species from 5000 pieces of vegetation.

Most of the specimens appeared to have been collected during the current summer, and foliage greatly predominated over flowers. In a few cases, especially with respect to Alpine Avens (*Geum*) flower stalks, the vegetation apparently had been cut and stored away in single-species bundles. Otherwise, the organization of plant material making up the pile was random. Incidental animal material included two millipedes, elk and pika dung, a ptarmigan feather, and some pika hair.

In late August of 1956 the area was checked to see if any additional hay had been stored. The amount was negligible. The area was again checked on July 13, 1957. Pikas were active on the talus slope and a small collection of "hay" was under one of the overhanging rocks where the previous summer's pile had been. This vegetation was almost exclusively old grass stems and blades and undoubtedly dated from the autumn of 1956. No fresh vegetation had yet been stored.

The numerical abundance of *Geum* in the hay pile is not unusual, inasmuch as the Avens is an extremely common alpine plant on Trail Ridge. Casual observations of hay piles here and in other areas suggest that pikas are, in the main, opportunists, gathering what is most readily available rather than exhibiting specific preferences. To what use the pikas were putting the hay was not determined but it presumably was utilized for food and bedding.—RICHARD G. BEIDLEMAN AND WILLIAM A. WEBER, *Biology Dept., Univ. of Colorado, Boulder.* *Received August 2, 1957.*

REVIEWS

Scheffer, Victor B. SEALS, SEA LIONS, AND WALRUSES. A review of the Pinnipedia. Stanford University Press, Stanford, California. Pp. x + 179, 15 figs., 32 pls. April 24, 1958. Price, $5.00.

To write a comprehensive book that encompasses, among other things, the structure, habits, evolution and classification of a mammalian order is a rather unique accomplishment. This, however, has been done with admirable skill by Dr. Victor B. Scheffer.

The pinnipeds, as a group, are world-wide in distribution although they are limited essentially to continental shores, islands, and polar ice fields in the breeding season. During this critical reproductive period, therefore, their distribution is essentially one-dimensional, comparable to that of alcids among birds, certain fishes and many marine invertebrates. This, as the author suggests, has probably had a marked influence on their evolutionary development.

Little is known regarding the origin of the pinnipeds since no fossil remains older than Miocene have, as yet, been found. Nevertheless, three possible progenitors have been proposed by various authors. The Pinnipedia may have arisen from insectivore-creodont stock back in the Cretaceous when cetaceans and sirenians were making their appearance. A second theory suggests that pinnipeds and fissipeds had a common origin from the creodonts back in the early Eocene. The third alternative is that pinnipeds branched off from the dog-raccoon-bear-weasel group of carnivores in the late Eocene. Although the author favors the second theory he grants that there is no evidence from paleontology, comparative anatomy or physiology to support any of these speculations. The real answer probably lies in pre-Miocene marine or fresh-water deposits as yet undiscovered.

Three factors are believed to have led to the stabilization (in a relative sense) of the modern genera, species and subspecies in this order. These are increased sociability, increased longevity and increased mobility. Seals, sea lions and walruses, in general, are much more sociable than land carnivores, suffer little from predation and disease and, for the most part, move about rather widely outside of the breeding season.

Although there are three recognized families of pinnipeds, members of this order exhibit considerable uniformity. All possess fusiform bodies ranging from medium to large in size. This is an adaptation to a cold environment. The smallest species is the ringed seal with a total length of about 55 inches and the largest is the southern elephant seal, the males of which may attain a length of 256 inches. All members of the order have the limbs modified into flippers and are more adapted to marine life than any carnivores although less so than cetaceans.

The author recognizes 20 genera and 31 species of living pinnipeds. Seven species exhibit some degree of subspeciation. In the taxonomic treatment, in addition to the synonomy and comments on the type, there is a detailed account of the range of each form. Rather useful to the specialist is a synoptic key to the genera.

The estimated numbers of living individuals of each species and subspecies are of special interest. This extremely useful information is presented concisely in one table. The total world population of seals, sea lions and walruses is estimated to be somewhere between 13,783,000 and 26,409,000. The great majority of pinnipeds belong to the family Phocidae.

Most of the important published literature on the order Pinnipedia is referred to in the text. As a result there is a very extensive bibliography. This careful documentation plus Dr. Scheffer's many years of personal experience with these animals and pleasing style of presentation has resulted in a book of fine quality which should prove of interest to the specialist and nonspecialist alike.—ROBERT T. ORR.

RECENT LITERATURE

(Prepared by the Committee on Bibliography)

[Reprints of this bibliographic section may be purchased from the Secretary-Treasurer. However, the Society cannot furnish reprints of the individual publications listed.]

ALEXEEVA, L. I. Sur la trouvaille de *Platybelodon grangeri* en Kirghizie. Vertebrata Palasiatica, 1 (3): 215–222, illus. September, 1957. (In Russian, with French summary.)

ANCIAUX DE FAVEAUX, FÉLIX. Chiroptères des grottes du Haut-Katange (Congo Belge). Bull. Inst. Français Afrique Nord, ser. A, 20 (1): 263–275. 1958.

ANDERSON, SYDNEY, AND PHILIP W. OGILVIE. Vertebrates found in owl-pellets from northeastern Chihuahua. Southwestern Naturalist, 2 (1): 33–37. October 15, 1957.

ANONYMOUS. The Nantucket Whaling Museum. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 47 (1): 6–17, illus. January, 1958.

ANTHONY, J. De l'intéret des caractères cérébraux pour la classification des ongulés. Mammalia, Paris, 22 (1): 53–57. March, 1958.

ARDRAN, G. M., F. H. KEMP, AND W. D. L. RIDE. A radiographic analysis of mastication and swallowing in the domestic rabbit: *Oryctolagus cuniculus* (L). Proc. Zool. Soc. London, 130 (2): 257–274, pls. 1–7. March 13, 1958.

ASHTON, E. H., AND T. F. SPENCE. Age changes in the cranial capacity and foramen magnum of hominoids. Proc. Zool. Soc. London, 130 (2): 169–181. March 13, 1958.

ATKESON, THOMAS Z. Shotguns versus rifles in gray squirrel hunting. Jour. Wildlife Management, 22 (1): 99–100. January, 1958.

BANNIKOV, A.-G. Distribution géographique et biologie du cheval sauvage et du chameau de Mongolie (*Equus przewalskii* et *Camelus bactrianus*). Mammalia, Paris, 22 (1): 152–160, pl. 6. March, 1958.

BARKER, S., A. R. MAIN, AND R. M. SADLEIR. Recent capture of the quokka (*Setonix brachyurus*) on the mainland. Western Australian Naturalist, 6 (2): 53–55. August 15, 1957.

BARNETT, S. A. An analysis of social behaviour in wild rats. Proc. Zool. Soc. London, 130 (1): 107–152, pls. 1–3. January 23, 1958.

BAUER, KURT. Neue Funde der Wimperfledermaus, *Myotis e. emarginatus* (Geoffroy, 1806), in Österreich. Säugetierk. Mitteil., 5 (3): 97–100. August 1, 1957.

BIEGERT, J. Der Formwandel des Primatenschädels und seine Beziehungen zur ontogenetischen Entwicklung und den phylogenetischen Spezialisationen der Kopforgane. Morphol. Jahrbuch, Leipzig, 98 (1): 77–199. 1957.

BLAIR, W. FRANK. Effects of x-irradiation on a natural population of the deer-mouse (*Peromyscus maniculatus*). Ecology, 39 (1): 113–118. January, 1958.

BOLLE, FRITZ. Ein Bild des Davidshirsches von Adolph Menzel. Säugetierk. Mitteil., 5 (3): 127–129, illus. August 1, 1957.

BONNER, W. NIGEL. Notes on the southern fur seal in South Georgia. Proc. Zool. Soc. London, 130 (2): 241–252, pls. 1–3. March 13, 1958.

BOOTH, ERNEST S. Mammals collected in Mexico from 1951 to 1956 by the Walla Walla College Museum of Natural History. Walla Walla College Publ., Dept. Biol. Sci. & Biol. Sta., 20: 1–19. July 10, 1957.

BOURDELLE, E., AND M. DEZILIERE. Sur quelques caractères ostéologiques et ostéometriques de la genette des Pyrénées dans le cadre des genettes de l'Europe occidentale et de la France en particulier. Bull. Soc. Hist. Nat. Toulouse, 86: 122–124. 1951. (New: *Genetta genetta pyrenaica.*)

BRÅNEMARK, PER-INGVAR. A method for vital microscopy of mammalian bone marrow in situ. Lunds Univ. Årsskrift, N.F. Avd. 2, 54 (2): 5–41. 1958.

BRIDGES, WILLIAM. Africa's champion digger. Animal Kingdom, New York Zool. Soc., 61 (1): 20–22, illus. February, 1958. (Aard-vark.)

BRUNNER, GEORG. Die Markgrabenhöhle bei Pottenstein (Oberfranken). Eine Fauna des Altdiluviums mit *Talpa episcopalis* Kormos u. a. Neues Jahrb. Geol. & Paläontol., Monatsh., Stuttgart, 1952 (10): 457–471, illus. October, 1952. (New: *Neomys intermedius.*)

BUBENIK, ANTONIN. Ein Takin, *Budorcas taxicolor bedfordi* Thomas, 1911, in Gefangenschaft. Säugetierk. Mitteil., 5 (4): 169, illus. December 1, 1957.

BURT, WILLIAM HENRY. Mammals of the Great Lakes region. Univ. Michigan Press, Ann Arbor, pp. xv + 246. 1957.

CABRERA, ANGEL. Catalogo de los mamíferos de América del Sur. I (Metatheria-Unguiculata-Carnivora). Rev. Mus. Argentino Ciencias Naturales "Bernardino Rivadavia," Cienc. Zool., 4 (1): 1–307. March 27, 1958. (New: Subgenus *Hesperomyotis.*)

CACHAN, P. Confirmation de la présence du pangolin géant en Basse Côte d'Ivoire. Mammalia, Paris, 21 (4): 455–457. December, 1957.

CAMERON, AUSTIN W. A guide to eastern Canadian mammals. National Museum of Canada, Ottawa, pp. v + 72, illus. 1956.

CARVALHO, CORY T. DE. Nova subespécie de saguim da Amazônia (Callithricidae, Primates). Rev. Brasileira Biol., 17 (2): 219–222. June, 1957. (New: *Leontocebus melanoleucus acrensis.*)

CARVALHO, CORY T. DE. Alguns mamíferos do Acre Ocidental. Bol. Mus. Paraense Emílio Goeldi, nova série, zool., 6: 1–22. August, 1957.

CHANG, HSI-CHIH. On new material of some machairodonts of Pontian age from Shansi. Vertebrata Palasiatica, 1 (3): 193–200. September, 1957.

CHIA, LAN-PO. Notes on the human and some other mammalian remains from Changyang, Hupei. Vertebrata Palasiatica, 1 (3): 247–258. September, 1957. (In Chinese, with English summary.)

CHITTLEBOROUGH, R. G. An analysis of recent catches of humpback whales from the stocks in Groups IV and V. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 47 (3): 109–137. March, 1958.

CHOW, MINCHEN M. On a mandible of *Palaeoloxodon* from Pekin, with discussion on the fossil elephants of *namadicus* group of China. Acta Paleontol. Sinica, 5 (2): 283–294, pls. 1–3. May, 1957. (In Chinese, with English summary.)

CHOW, MINCHEN. On some Eocene and Oligocene mammals from Kwangsi and Yunnan. Vertebrata Palasiatica, 1 (3): 201–214. September, 1957. (New: *Lunania, L. youngi*; *Caenolophus medius.*)

CHOW, MINCHEN. A new *Coryphodon* from Sintal, Shantung. Vertebrata Palasiatica, 1 (4): 301–304. December, 1957. (New: *Coryphodon flerowi.*)

CLARK, EUGENE S., JR. Right whale (*Balaena glacialis*) enters Cape Cod Canal, Massachusetts, U.S.A. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 47 (3): 138–143. March, 1958.

CONSTANTINE, DENNY G. An automatic bat-collecting device. Jour. Wildlife Management, 22 (1): 17–22, illus. January, 1958.

COUTURIER, MARCEL A. J. Trophée d'isard (*Rupicapra rupicapra pyrenaica* Bonaparte 1845) record des Pyrénées françaises espagnoles et andorraïnnes. Mammalia, Paris, 21 (4): 381–384, pl. 11. December, 1957.

COUTURIER, MARCEL A. J. Parallèle anatomique, physiologique et écologique entre le pied du bouquetin des Alpes (*Capra aegagrus ibex ibex*) et celui du chamois (*Rupicapra rupicapra*) en rapport avec l'adaptation a la montagne de ces deux espèces. Mammalia, Paris, 22 (1): 76–89, pls. 1–2. March, 1958.

CRUSAFONT-PAIRO, M. Nouvelles vues sur la classification paléontologique des Pecora.

Mammalia, Paris, 22 (1): 45–52. March, 1958.

DAVIES, J. L. Pleistocene geography and the distribution of northern pinnipeds. Ecology, 39 (1): 97–113. January, 1958.

DEMENTIEV, G.-P. Quelques notes sur l'aurochs. Mammalia, Paris, 22 (1): 161–167. March, 1958.

DORST, JEAN. A propos d'un spécimen de Bubale d'Afrique du Nord conservé dans les collections du Muséum. Bull. Mus. Nat. Hist. Nat. Paris, ser. 2, 29 (6): 447–450. February 25, 1958.

DORST, JEAN. Systématique et biologie des ongulés. Colloque organisé par Mammalia. Avant-propos. Mammalia, Paris, 22 (1): 1–8. March, 1958.

DUBROVO, I. Der erste Nachweis des fossilen Jak im nördlichen Ostsibirien (Jakutsk). Vertebrata Palasiatica, 1 (4): 293–300. December, 1957. (In Russian, with German and Chinese summaries.)

DURUP, HENRI. Une classification mathématique des rythmes biologiques fluctuants. Mammalia, Paris, 21 (4): 420–429. December, 1957.

EADIE, W. ROBERT, AND W. J. HAMILTON, JR. Reproduction in the fisher in New York. New York Fish & Game Jour., 5 (1): 77–83. January, 1958.

EBHARDT, HERMANN. Drei unterschiedliche Verhaltensweisen von Islandpferden in norddeutschen Freigehegen. Säugetierk. Mitteil., 5 (3): 113–117. August 1, 1957.

EDMOND-BLANC, F. Observations sur le comportement de la panthère et du lion. Mammalia, Paris, 21 (4): 452–453. December, 1957.

EDMOND-BLANC, F. Observations sur deux antilopes albinos. Mammalia, Paris, 21 (4): 453–454. December, 1957.

EISENTRAUT, M., AND H. KNORR. Les chauves-souris cavernicoles de la Guinée Française. Mammalia, Paris, 21 (4): 321–335. December, 1957.

FAY, FRANCIS H. History and present status of the Pacific walrus population. Trans. 22nd North Amer. Wildlife Conference, Washington, pp. 431–445. 1958.

FEEN, P. J. VAN DER. Les chevaux fossiles et subfossiles des Pays-bas. Mammalia, Paris, 22 (1): 69–72. March, 1958.

FELTEN, HEINZ. Quiropteros (*Mammalia, Chiroptera*) en El Salvador. Comunic. Inst. Trop. Investig. Cien. Univ. El Salvador, 5 (4): 153–170, 14 pls. October–December, 1956.

FIELDS, ROBERT W. Hystricomorph rodents from the late Miocene of Colombia, South America. Univ. California Publ. Geol. Sci., 32 (5): 273–404, illus. December 11, 1957. (New: *Scleromys colombianus, Prodolichotis pridiana, Neoreomys huilensis.*)

FRASER, F. C. Common or harbour porpoises from French West Africa. Bull. Inst. Français Afrique Nord, ser. A, 20 (1): 276–285. 1958.

FRECHKOP, S. Des critères de la systématique des ongulés. Mammalia, Paris, 22 (1): 12–27. March, 1958.

FREEDMAN, L. The status of *Papio rhodesiae* (Haagner) 1918. Ann. Transvaal Mus., 22 (3): 267–270, pl. 22. January 24, 1955.

FRIANT, MADELEINE. Morphologie et developpement du cerveau des mammifères eutheriens et de l'homme, II. Série des Primates. Ann. Soc. Roy. Zool. Belgique, 87 (1): 91–150. 1957.

FURRER, MARTIN. Ökologische und systematische Übersicht über die Chiropteren-fauna der Schweiz. Inaugural-Dissertation Univ. Zürich, pp. 1–87. 1957.

GAUTHIER-PILTERS, H. Quelques observations sur l'ecologie et l'ethologie du dromadaire dans le Sahara nord-occidental. Mammalia, Paris, 22 (1): 140–151. March, 1958.

GEWALT, WOLFGANG. Über das Schwimmen von Eichhorn, *Sciurus vulgaris fuscoater*, Feldhase, *Lepus e. europaeus*, und Reh, *Capreolus c. capreolus*. Säugetierk. Mitteil., 5 (4): 162–164. December 1, 1957.

GIER, H. T. Coyotes in Kansas. Bull. Kansas State College Agric. Exper. Sta., Manhattan, 3: 1–96, illus. August, 1957.

GIJZEN, AGATHA. Quelques observations concernant la naissance et la croissance de girafes (*Giraffa camelopardalis antiquorum* (Swainson)) au Jardin Zoologique d'Anvers. Mammalia, Paris, 22 (1): 112–120, pl. 5. March, 1958.

GOODWIN, GEORGE G. Two new mammals from México. Amer. Mus. Novitates, 1871: 1–3. February 26, 1958. (New: *Pteronotus suapurensis calvus, Sigmodon hispidus villae.*)

GOODWIN, GEORGE G. Three new bats from Trinidad. Amer. Mus. Novitates, 1877: 1–6. February 28, 1958. (New: *Chiroderma trinitatus, Cynomops greenhalli, Glossophaga major.*)

GORDEEV, T. P., AND V. N. JERNAKOV. A skeleton of the fossil rhinoceros found in the vicinity of Fuliaerhtzi Station of the Heilungchiang Province. Vertebrata Palasiatica, 1 (3): 233–246. September, 1957. (In Russian, with English summary.)

GREEN, MORTON. *Gomphotherium fricki* from Bijou Hills, South Dakota. Proc. South Dakota Acad. Sci., 36 (for 1957): 139–142, illus. 1958.

GRZIMEK, BERNHARD. Delphine helfen kranken Artgenossen. Säugetierk. Mitteil., 5 (4): 160–162. December 1, 1957.

GUILER, ERIC R., AND DORIS M. BANKS. A further examination of the distribution of the brush possum *Trichosurus vulpecula* in Tasmania. Ecology, 39 (1): 89–97. January, 1958.

HALLORAN, ARTHUR F., AND OSCAR V. DEMING. Water development for desert bighorn sheep. Jour. Wildlife Management, 22 (1): 1–9, illus. January, 1958.

HANDLEY, CHARLES O., JR. A new Pleistocene bat (*Corynorhinus*) from Mexico. Jour. Washington Acad. Sci., 45 (2): 48–49. March 16, 1955. (New: *C. tetralophodon.*)

HARRISON, DAVID L. Notes on some bats (*Microchiroptera*) from Iraq. Bonner Zool. Beiträge, 7 (1–3): 1–7. 1956.

HARRISON, DAVID L. A note on the occurrence of the woolly bat, *Kerivoula cuprosa* Thomas in Kenya. Rev. Zool. & Bot. Africaine, 55 (1–2): 47–48. March 27, 1957.

HARRISON, DAVID L. Two bats (Microchiroptera) new to the fauna of Tanganyika Territory. Durban Mus. Nov., 5 (7): 95–98. February 15, 1958.

HARRISON, J. L. Malaysian parasites—XXXIII. The hosts. Studies from the Institute for Medical Research, Federation of Malaya, 28: 409–426. 1957.

HEIM DE BALSAC, H. Insectivores *Soricidae* du Mont Cameroun. Zool. Jahrb., 85 (6): 607–618. December 18, 1957. (New: *Crocidura eisentrauti.*)

HELLER, FLORIAN. Die Fauna, *in* Das Paläolithikum in den Weinberghöhlen bei Mauern, by L. Zotz. Quartärbibliothek, 2: 220–307, illus. 1955. (New: *Arvicola gracilis.*)

HELLER, FLORIAN. Fauneninhalt und Schichten der Jungfernhöhle, *in* "Die Jungfernhöhle bei Tiefenellern," by Otto Kunkel. Münchner Beiträge zur Vor-Frühgeschichte, 5: 52–64. 1955.

HELLER, FLORIAN. Ein kleinerer Bär (*Ursus sackdillingensis* n. sp.) in der cromerischen Fauna der Sackdillinger-Höhle (Oberpfalz). Neues Jahrb. Geol. & Paläontol., Monatsh., 12: 520–530, illus. January, 1956.

HELLER, FLORIAN. Die fossilen Gattungen *Mimomys* F. Maj., *Cosomys* Wil. und *Ogmodontomys* Hibb. (*Rodentia, Microtinae*) in ihren systematischen Beziehungen. Acta Zool. Cracoviensia, Polska Akad. Nauk, 2 (10): 219–237, table. August 31, 1957. (In German, with Polish and Russian summaries.)

HELLER, FLORIAN. Funde und Beobachtungen im Hohlen Stein bei Schambach, Lkr. Erchstatt. (Zur Frage der Höhlenbären-Schädeldepositionen.) Quartar, 9: 161–170. 1957.

HERSHKOVITZ, PHILIP. On the possible occurrence of the spectacled bear, *Tremarctos ornatus* (F. Cuvier, 1825), in Panama. Säugetierk. Mitteil., 5 (3): 122–123,

illus. August 1, 1957.

HERSHKOVITZ, PHILIP. A synopsis of the wild dogs of Colombia. Novedades Colombianas, Mus. Nat. Hist. Univ. del Cauca, 3: 157–161. December 1, 1957.

HETTRICK, HAROLD D. Danger: deer crossing. Wisconsin Conservation Bull., 23 (3): 7–9. March, 1958. (Deer killed by automobiles.)

HIBBARD, CLAUDE W. Notes on late Cenozoic shrews. Trans. Kansas Acad. Sci., 60 (4): 327–336, illus. February, 1958. (New: *Hesperosorex, H. lovei*; *Cryptotis kansasensis.*)

HIBBARD, CLAUDE W. Summary of North American Pleistocene mammalian local faunas. Papers Michigan Acad. Sci., Arts, & Letters, 43 (for 1957): 3–32. March 20, 1958.

HOFFMANN, ROBERT S. The role of reproduction and mortality in population fluctuations of voles (*Microtus*). Ecological Monographs, 28: 79–109. January, 1958.

HOFFSTETTER, ROBERT. Les mammifères pléistocènes de la République de l'Equateur. Mem. Soc. Geol. France, Paris (nouv. sér.), 66: 1–391, pls. 1–8. 1952. (New: *Glossotherium tropicorum, Scelidotherium reyesi, Chlamytherium occidentale, Dusicyon sechurae elenensis, Protocyon orcesi, Panthera onca andina, Aleamastodon, Haplomastodon guayasensis, Palaeolama aequatorialis, P. crassa, Agalmaceros.*)

HOGUE, JACK. The red fox. Colorado Outdoors Mag., 7 (1): 12–14, illus. January, 1958.

HOOGSTRAAL, HARRY, AND MAKRAM N. KAISER. Observations on Egyptian Hyalomma ticks (Ixodoidea, Ixodidae). 3. Infestation of greater gerbils, especially by immature H. impelatatum S. & S. Ann. Entomol. Soc. Amer., 51 (1): 17–19. January, 1958.

HOOIJER, D. A. A Stegodon from Flores. Treubia, 24 (1): 119–129, pls. 2–3. December 15, 1957. (New: *S. trigonocephalus florensis.*)

HOOIJER, D. A. Sexual differences in the skull of fossil and recent bantengs. Mammalia, Paris, 22 (1): 73–75. March, 1958.

HSU, YU-HSIUAN, YU-CH'ING LEE, AND HSIANG-HSU HSIEH. Mammalian fossils from the Pleistocene cave deposits of Chihchin, northwestern Kweichow. Acta Paleont. Sinica, 5 (2): 343–350, pl. 1. May, 1957.

HÜRZELER, JOHANNES. Oreopithecus bambolii Gervais. Verh. Naturf. Ges. Basel, 69 (1): 1–48. January, 1958.

JAMESON, E. W., JR. The cost and effectiveness of controlling *Microtus* by zinc phosphide. Jour. Wildlife Management, 22 (1): 100–103. January, 1958.

JONES, J. KNOX, JR. A dental abnormality in the shrew, Crocidura lasiura. Trans. Kansas Acad. Sci., 60 (1): 88–89, illus. 1957.

JONES, J. KNOX, JR. Type hosts of the bat trematodes, *Prosthodendrium oligolecithum* Manter and Debus, 1945, and *Acanthatrium macyi* Sogandares-Bernal, 1956. Jour. Parasitol., 43 (2): 185. April, 1957.

KAHLKE, H. D., AND CHANGKANG HU. On the distribution of *Megaceros* in China. Vertebrata Palasiatica, 1 (4): 273–283, illus. December, 1957.

KAHMANN, HERMAN, AND HELMUT ALTNER. Die Verbreitung des Abendseglers, *Nyctalus noctula* (Schreber, 1774), auf den Tyrrhenischen Inseln und Sizilien. Säugetierk. Mitteil., 5 (3): 120–121. August 1, 1957.

KARASEVA, E. V., E. V. NARSKAYA, AND A. D. BERNSTEIN. The *Microtus oeconomus* inhabiting the neighbourhood of Lake Nero in Yaroslav region. Bull. Moskovskogo Obshchestva Ispytatelei Prirody, Biol., 62 (3): 5–18. May–June, 1957. (In Russian with English summary.)

KEMPERS, BURT. The wild dogs. Colorado Outdoors Mag., 7 (1): 16–17, illus. January, 1958. (Wild canids of Colorado.)

KIMBALL, THOMAS L. Why a liberal deer season? Colorado Outdoors Mag., 7 (1): 1–5, illus. January, 1958.

KINDAHL, MÄRTHA. Some observations on the development of the tooth in *Elephantulus myurus Jamesoni*. Arkiv för Zoologi, Stockholm, 11 (2): 21–29. February 5, 1958.

KINDAHL, MÄRTHA. Notes on the tooth development in *Talpa europaea*. Arkiv för Zoologi, Stockholm, 11 (13): 187–191. February 5, 1958.

KITTS, DAVID B. A saber-tooth cat, *Smilodon californicus* Bovard, from Logan County, Oklahoma. Oklahoma Geol. Notes, Oklahoma Geol. Surv., 18 (2): 19–23, illus. February, 1958.

KLEMMER, KONRAD. Eine Methode zum Fang fliegender Fledermäuse. Säugetierk. Mitteil., 5 (3): 118–120. August 1, 1957.

KÖNIG, CLAUS, AND AUGUST EPPLE. Die Wimperfledermaus, *Myotis emarginatus* (Geoffroy, 1806), auch in der Pfalz. Säugetierk. Mitteil., 5 (3): 123–124. August 1, 1957.

KOZLOV, V. V. Wild boars in Ryazan region. Zool. Zhurnal, 37 (1): 142–143. January, 1958. (In Russian, with English summary.)

KOWALSKI, KAZIMIERZ. An early Pleistocene fauna of small mammals from the Kadzielnia Hill of Kielce (Poland). Acta Palaeontol. Polonica, 3 (1): 1–47. 1958. (New: *Dolomys kretzoii, Promimomys insuliferus.*)

KRAFT, HELMUT. Das Verhalten von Muttertier und Neugeborenen bei Cameliden. Säugetierk. Mitteil., 5 (4): 174–175. December 1, 1957.

KRAFT, HELMUT. Lethargie-Zustand eines Weisspinseläffchens, *Callithrix jacchus* (Linné, 1766). Säugetierk. Mitteil., 5 (4): 175–176. December 1, 1957.

KRYLTSOV, A. I. Material on the moulting in Muridae. I. Moulting in mass species of Microtinae in northern Kazakhstan. Zool. Zhurnal, 37 (2): 271–286. February, 1958. (In Russian, with English summary.)

KURTÉN, BJÖRN. *Percrocuta* Kretzoi (*Mammalia, Carnivora*), a group of Neogene hyenas. Acta Zool. Cracoviensia, Polska Akad. Nauk, 2 (16): 375–404. December 15, 1957. (In English, with Polish and Russian summaries. New: *Crocuta* (*Percrocuta*) *grandis.*)

LANG, ERNST M. Stimmlicher Kontakt von Okapis untereinander. Säugetierk. Mitteil., 5 (4): 171. December 1, 1957.

LAVOCAT, R. Classification des ongulés d'après leur origine et leur évolution. Mammalia, Paris, 22 (1): 28–40. March, 1958.

LAWS, R. M. Growth rates and ages of crabeater seals, *Lobodon carcinophagus* Jacquinot & Pucheran. Proc. Zool. Soc. London, 130 (2): 275–288, pls. 1–2. March 13, 1958.

LEGOUIX, J. P. L'audition chez les mammifères. Mammalia, Paris, 21 (4): 396–404. December, 1957.

LENGERKEN, HANNS v. Unbeständigkeit der Lendenwirbelzahl beim Przewalskipferd, Hauspferd und Hausschwein. Säugetierk. Mitteil., 5 (4): 157–160. December 1, 1957.

LINDSAY, GEORGE E. Eskimo whaling at Point Barrow. Zoonooz, Zool. Soc. San Diego, 30 (12): 3–6, illus. December, 1957.

LUNDHOLM, B. G. Descriptions of new mammals. Ann. Transvaal Mus., 22 (3): 279–305. January 24, 1955. (New: *Crocidura malani, C. luna inyangai, Elephantulus vandami montanus, E. intufi canescens, E. rupestris fitzsimonsi, Macroscelides proboscideus flavicaudatus, Carpitalpa, Kilimatalpa, Chlorotalpa* (*Carpitalpa*) *arendsi, Viverra civetta australis, V. c. volkmanni, Herpestes nigratus annulatus, Felis serval ingridi, Lepus capensis carpi, Pronolagus crassicaudatus ekmani, Heliosciurus gambianus smithersi, Paraxerus cepapi carpi, Otomys maximus davisi, Gerbillus paeba infernus, Gerbillurus vallinus seeheimi, Desmodillus auricularis shortridgei, D. a. robertsi, Dendromus longicaudatus bernardi, Petromyscus collinus rufus, P. c. variabilis, Thallomys nigricauda davisi, T. n. zambesiana, Petromus typicus greeni, P. t. pallidior.*)

LUNDHOLM, B. G. A taxonomic study of *Cynictis penicillata* (G. Cuvier). Ann. Transvaal

Mus., 22 (3): 305–319. January 24, 1955.

LUNDHOLM, B. G. Remarks on some South African Murinae. Ann. Transvaal Mus., 22 (3): 321–329, illus. January 24, 1955.

MARKOV, GEORGI. Nasekomoyadite bozainitsi v. Bulgariya. Bulgarska Akad. Nauk, Zool. Inst., Sofia, Fauna na Bulgariya, no. 3, pp. 287. 1957. (Insectivorous mammals of Bulgaria.)

MATTHEY, ROBERT. Cytologie et taxonomie du genre *Meriones*, Illiger (Rodentia-Muridae-Gerbillinae). Säugetierk. Mitteil., 5 (4): 145–150, illus. December 1, 1957.

MCLAUGHLIN, CHARLES A. A new race of the pocket gopher *Geomys bursarius* from Missouri. Contrib. Sci. Los Angeles County Mus., 19: 1–4. January 29, 1958. (New: *G. b. missouriensis.*)

MEYER, ISOLDE. Beiträge zur Kenntnis der Fussohlenbehaarung bei den *Lagomorpha*. Zool. Anzeiger, Leipzig, 160 (1–2): 7–20. January, 1958.

MEYER-HOLZAPFEL, MONIQUE. Bouquetins en captivité. Mammalia, Paris, 22 (1): 90–103, pls. 3–4. March, 1958.

MILLOT, PIERRE. Les groupes sanguins chez les ongulés. Mammalia, Paris, 22 (1): 58–68. March, 1958.

MIYAZAKI, ICHIRO. Fin whales and whaling operations in the East China Sea. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 47 (1): 21–26. January, 1958.

MÖHRES, FRANZ PETER, AND ERWIN KULZER. Megaderma—ein konvergenter Zwischentyp der Ultraschallpeilung bei Fledermäusen. Die Naturwissenschaften, 44 (1): 21–22. 1957.

MONDOLFI, EDGARDO, AND GONZALO MEDINA PADILLA. Contribucion al conocimiento del "perrito de agua" (*Chironectes minimus* Zimmerman). Mem. Soc. Cien. Nat. La Salle, Caracas, 17 (48): 141–155. 1957.

MOORE, JOSEPH CURTIS. New striped tree squirrels from Burma and Thailand. Amer. Mus. Novitates, 1879: 1–6. February 28, 1958. (New: *Tamiops mcclellandi collinus, T. rodolphei elbeli.*)

MURRAY, KEITH F. Pleistocene climate and the fauna of Burnet cave, New Mexico. Ecology, 38 (1): 129–132. January, 1957.

NERO, ROBERT W. Coyote tolling a calf. Blue Jay, Saskatchewan Nat. Hist. Soc., 16 (1): 32–33. March, 1958.

NERO, ROBERT W. Gray squirrel (*Sciurus carolinensis*) in Saskatchewan. Blue Jay, Saskatchewan Nat. Hist. Soc., 16 (1): 33–35. March, 1958.

NEUHAUS, W. Hohes Alter einer Waldmaus, *Apodemus sylvatius* (Linné, 1758). Säugetierk. Mitteil., 5 (4): 171–172. December 1, 1957.

NOUVEL, J. Remarques sur la fonction génitale et la naissance d'un okapi. Mammalia, Paris, 22 (1): 107–111. March, 1958.

NOVICK, ALVIN. Notes on an additional example of the fruit bat, *Scotonycteris ophiodon* Pohle. Postilla, Yale Peabody Mus. Nat. Hist., 34: 1–5. March 7, 1958.

OETTINGEN-SPIELBERG, THERESE ZU. Ein oberoligocäner Tapirfund von Gaimersheim bei Ingolstadt in Bayern. Neues Jahrb. Geol. & Paläontol., Stuttgart, 94 (2–3): 401–428, pl. 28. March, 1952. (New: *Tapirus bavaricus.*)

OLIVIER, GEORGES, AND GUY PIGANIOL. Le fémur du semnopithèque. Mammalia, Paris, 21 (4): 430–451, pl. 12. December, 1957.

PAKIZH, V. I. Distribution of Citellus citellus L. in Moldavian SSSR and certain data on its bionomics. Zool. Zhurnal, 37 (1): 105–119. January, 1958. (In Russian, with English summary.)

PETZSCH, HANS. Richtigstellung zur Arbeit "Beobachtungen an winterschlafenden Goldhamstern, *Mesocricetus auratus* (Waterhouse, 1839)" von A. Fellner. Säugetierk. Mitteil., 5 (3): 126–127. August 1, 1957.

PFEFFER, PIERRE. Notes sur le peuplement mammalien des îles de Florès, Komodo et

Rintja (petites iles de la Sonde). Mammalia, Paris, 21 (4): 405–419. December, 1957.

PIMLOTT, D. H., AND W. J. CARBERRY. North American moose transplantations and handling techniques. Jour. Wildlife Management, 22 (1): 51–62, illus. January, 1958.

PIRLOT, P. L. Croissance et maturité sexuelle chez *Mastomys coucha* Smith. Mammalia, Paris, 21 (4): 385–395. December, 1957.

PITELKA, FRANK A. Some aspects of population structure in the short-term cycle of the brown lemming in northern Alaska. Cold Spring Harbor Symposia on Quantitative Biology, 22: 237–251. 1957.

PITELKA, FRANK A. Some characteristics of microtine cycles in the Arctic. Arctic Biology, Biology Colloquium Proceedings, 18: 73–88. 1957.

POURNELLE, GEORGE H. From reptiles to marsupials in 180,000,000 years. Zoonooz, Zool. Soc. San Diego, 31 (1): 10–14, illus. January, 1958. (Marsupials in San Diego zoo.)

PRESNALL, CLIFFORD C. The present status of exotic mammals in the United States. Jour. Wildlife Management, 22 (1): 45–50. January, 1958.

PRYCHODKO, WILLIAM. Über die Verkehrsopfer freilebender Tiere auf den Autobahnen im Südosten von Michigan. Säugetierk. Mitteil., 5 (4): 151–156. December 1, 1957.

PRYCHODKO, W. Das Vorkommen von asymetrischer Anordnung der Brustwarzen beim kalifornischen Erdhörnchen, *Citellus beecheyi* (Richardson, 1829). Säugetierk. Mitteil., 5 (4): 168–169. December 1, 1957.

PSENNER, HANS. Die ersten Nachweise des Tiroler Baumschläfers, *Dryomys nitedula intermedius* (Nehring, 1902), für Nordtirol. Säugetierk. Mitteil., 5 (4): 172. December 1, 1957.

PSENNER, HANS. Zur Frage: Mauswiesel-Zwergwiesel. Säugetierk. Mitteil., 5 (4): 172. December 1, 1957.

REID, MARY ELIZABETH. The guinea pig in research: biology, nutrition, physiology. Publ. No. 557, Human Factors Research Bureau, Nat. Press Bldg., Washington, D. C., pp. 1–87. 1958.

REINWALDT, EDWIN. Studien am Schädel der schwedischen Waldmäuse, *Apodemus sylvaticus* (Linné, 1758) und *Ap. flavicollis* (Melchior, 1834). Säugetierk. Mitteil., 5 (3): 100–103. August 1, 1957.

REINWALDT, EDWIN. Verwendung von Rotan beim Anfertigen von Kleinsäugerbälgen. Säugetierk. Mitteil., 5 (4): 169. December 1, 1957.

REMPE, UDO. Beobachtungen über Brunst, Paarung, Tragzeit, Geburt und Kreuzungen bei Mitgliedern der Untergattung *Putorius*. Säugetierk. Mitteil., 5 (3): 111–113. August 1, 1957.

RIPLEY, S. DILLON. Comments on the black and square-lipped rhinoceros species in Africa. Ecology, 39 (1): 172–174. January, 1958.

RUSSELL, LORIS S. Paleocene mammal teeth from Alberta. Bull. Nat. Mus. Canada, 147 (Ann. Rept. 1955–56): 96–103, illus. 1958.

SANBORN, COLIN CAMPBELL, AND JORGE A. CRESPO. El murciélago blanquizco (*Lasiurus cinereus*) y sus subespecies. Bol. Mus. Argentino Cienc. Nat. "Bernardino Rivadavia," Buenos Aires, 4: 1–13. 1957.

SANTY, DAVE. Unusual animals of the Beechy district. Blue Jay, Saskatchewan Nat. Hist. Soc., 16 (1): 36–37. March, 1958.

SCHAEFER, HELMUT. Säugetierkundliches aus Workuta, Nordrussland. Säugetierk. Mitteil., 5 (4): 165–168. December 1, 1957.

SCHLOETH, ROBERT. Cycle annuel et comportment social du taureau de Camargue. Mammalia, Paris, 22 (1): 121–139, illus. March, 1958.

SCHULLER, LINDE. Vom "Wachen" der Hunde. Säugetierk. Mitteil., 5 (3): 106–111.

August 1, 1957.

SCHULLER, LINDE. Zur Euter-Suche junger Huftiere. Säugetierk. Mitteil., 5 (4): 170. December 1, 1957.

SCHULTZ, ADOLPH H. Cranial and dental variability in colobus monkeys. Proc. Zool. Soc. London, 130 (1): 79–105, pl. 1. January 23, 1958.

SERAFIŃSKA, JANINA, AND WŁODZIMIERZ SERAFIŃSKI. Einige seltenere oder weniger bekannte Säugetierformen aus dem Nida-Tal. Acta Zool. Cracoviensia, Polska Acad. Nauk, 2 (9): 208–217. August 31, 1957. (In Polish, with German and Russian summaries.)

SHARP, WARD M. Aging gray squirrels by use of tail-pelage characteristics. Jour. Wildlife Management, 22 (1): 29–34, illus. January, 1958.

SLIJPER, E. J. Birth in ungulates. Mammalia, Paris, 22 (1): 104–106. March, 1958.

STAINS, HOWARD J. Field key to guard hairs of Middle Western furbearers. Jour. Wildlife Management, 22 (1): 95–97. January, 1958.

SWANK, WENDELL G. The mule deer in Arizona chaparral. Arizona Game & Fish Dept., Wildlife Bull. 3, pp. 1–109, illus. February, 1958.

SYMONS, H. W., AND R. D. WESTON. Studies on the humpback whale (*Megaptera nodosa*) in the Bellingshausen Sea. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), 47 (2): 53–81. February, 1958.

THOMPSON, SAMUEL W., AND THEODORE H. REED. Toxoplasmosis in a swamp wallaby. Jour. Amer. Vet. Med. Assoc., 131 (12): 545–549, illus. December 15, 1957.

TOBEIN, HEINZ. *Cuon* Hodg. und *Gulo* Frisch (Carnivora, Mammalia) aus den altpleistozänen Sanden von Mosbach bei Wiesbaden. Acta Zool. Cracoviensia, Polska Akad. Nauk, 2 (18): 433–452. December 20, 1957. (In German, with Polish and Russian summaries.)

TOMILIN, A. G. Some data on the thermoregulation in Muscardinus avellanarius. Change of the respiration character and body temperature during dormancy and activity. Zool. Zhurnal, 37 (1): 120–139. January, 1958. (In Russian, with English summary.)

TONG, E. H. Notes on the breeding of the Indian rhinoceros, Rhinoceros unicornis, at Whipsnade Park. Proc. Zool. Soc. London, 130 (2): 296–299. March 13, 1958.

TORTONESE, ENRICO. Il cetaceo odontocete *Ziphius cavirostris* G. Cuv. nel Golfo di Genova. Doriana, Suppl. Ann. Mus. Civ. Storia Nat. Genova, 2 (71): 1–7, illus. March 6, 1957.

TRUMLER, EBERHARD. Ein Hartmann-Zebra, *Equus zebra hartmannae* Matschiè, 1898, mit Zwischenstreifen. Säugetierk. Mitteil., 5 (4): 173–174, illus. December 1, 1957.

TUPIKOVA, N. V. Duration of maintenance of placental spots in Lagurus lagurus. Zool. Zhurnal, 37 (2): 308–311. February, 1958. (In Russian, with English summary.)

TURČEK, F. J. Zur Verbreitung der Bisamratte, *Ondatra zibethica* (Linné, 1766), in der Slowakei. Säugetierk. Mitteil., 5 (3): 104–106. August 1, 1957.

TURČEK, F. J. Bemerkungen zur Überwinterung der Feldmaus, *Microtus arvalis* (Pallas, 1779), auf Borstgras-Wiesen. Säugetierk. Mitteil., 5 (4): 170. December 1, 1957.

VAMBURKAR, S. A. The male genital tract of the Indian megachiropteran bat *Cynopterus sphinx gangeticus* And. Proc. Zool. Soc. London, 130 (1): 57–77, pls. 1–2. January 23, 1958.

VANSTONE, JAMES W. Commercial whaling in the Arctic Ocean. Pacific Northwest Quart., 49 (1): 1–10. January, 1958.

VIBE, CHR. The musk ox in east Greenland. Mammalia, Paris, 22 (1): 168–174, pl. 7. March, 1958.

VOIPIO, PAAVO. Some remarks on the taxonomy of Finnish squirrels. Archivum Soc. Zool. Bot. Fennicae "Vanamo," 11 (2): 97–107. 1956.

VOLF, JIRI. A propos de la reproduction du fennec. Mammalia, Paris, 21 (4): 454–455. December, 1957.

VORONTSOV, N. N. A new species of the fat-tailed jerboa (Pygerethmus vinogradovi, sp. n.) from the Zaissan's Hollow and some notes on the jerboa of the genus Pygerethmus Gloger (Dipodidae, Rodentia, Mammalia). Zool. Zhurnal, 37 (1): 96–104. January, 1958. (In Russian, with English summary.)

WALLING, J. J. Présence de la barbastelle en Bretange. Mammalia, Paris, 21 (4): 455. December, 1957.

WOO, JU-KANG, AND MINCHEN CHOW. New materials of the earliest primate known in China. Vertebrata Palasiatica, 1 (4): 267–272, illus. December, 1957.

WOOD, JOHN E., DAVID E. DAVIS, AND E. V. KOMAREK. The distribution of fox populations in relation to vegetation in southern Georgia. Ecology, 39 (1): 160–162. January, 1958.

YOUNGMAN, PHILLIP M. Geographic variation in the pocket gopher, Thomomys bottae, in Colorado. Univ. Kansas Publ., Mus. Nat. Hist., 9 (12): 363–384. February 21, 1958. (New: *T. b. rubidus.*)

ZAHAVI, A., AND J. WAHRMAN. The cytotaxonomy, ecology and evolution of the gerbils and jirds of Israel (Rodentia: Gerbillinae). Mammalia, Paris, 21 (4): 341–380. December, 1957.

ZIMMERMANN, K. Hermelin-Beute und überwinternde Gelbhalsmäuse in Nistkästen. Säugetierk. Mitteil., 5 (3): 129. August 1, 1957.

ZUKOWSKY, LUDWIG, AND THEODOR HALTENORTH. Das Erdferkel (*Orycteropus afer*) aus Angola, eine eigene Unterart? Säugetierk. Mitteil., 5 (3): 124–126, illus. August 1, 1957. (New: *O. a. angolensis.*)

PERSONAL NOTICES

This space is available to members of the Society for brief notices of interest to mammalogists. Copy should be sent to the editor by the 10th of the month preceding publication. Rates for single insertion are 25 cents per line or portion thereof. Bills will be rendered following publication.

FOR SALE—*Japanese "Mist" Bat Nets.* Send for price list. W. B. Davis, 254 F.E., College Station, Texas.

FOR SALE—*Live desert rodents.* Send for information and price list. Keith E. Justice, 44 W. Rillito St., Tucson, Arizona.

WANTED—*Preserved specimens,* just hatched or born, full term; all species; identified; maximum 12 hours. David Wetherbee, Hampton, Connecticut.

KEY TO THE SKULLS OF NORTH AMERICAN MAMMALS, by Bryan P. Glass, has been reprinted and may be ordered from the Research Foundation, Oklahoma State University, Stillwater, Oklahoma. Price $2.00 as in the past.

FOR *Sherman Live Traps* write H. B. Sherman, P.O. Box 683, De Land, Florida.

FOR SALE—*Journal of Mammalogy,* Vols. 1–8, bound in two volumes; Vols. 9–21, bound separately; Vols. 22–39, unbound; two Indexes; *Journal of Asinology,* Nos. 1–3; all for $300 —you pay the freight. Colin Campbell Sanborn, Marcella, Arkansas.

AVAILABLE FOR RESEARCH—Small numbers of laboratory-reared *Peromyscus leucopus* can be supplied for research purposes. Payment of handling and shipping costs appreciated. Charles H. Southwick, Dept. of Zoology, Ohio University, Athens, Ohio.

COMMENTS AND NEWS

MEMBERSHIP LIST

A new List of Members is to be published in the issue of May, 1959. Addresses will be those of record on February 1 and any changes should be reported to the Secretary–Treasurer before that date.

PRIMATE BEHAVIOR

A study of behavior in wild apes and monkeys, which may have a bearing on the problem of human evolution, is being undertaken in The Netherlands. Especially desired are field data on aggressive or defensive behavior and on the use of "tools" or "weapons." Particularly needed are accurate personal observations from South America, western Africa and India. Anyone willing to answer a questionnaire on these topics is invited to contact Dr. A. Kortlandt, Zoölogisch Laboratorium, Universiteit van Amsterdam, Plantage Doklaan 44, Amsterdam-C, Nederland.

TO MEMBERS RESIDING ABROAD

Attendance of foreign members at the annual meeting of the Society, to be held at Washington, D.C., next June 21–24, may be facilitated by a special letter of invitation from the Society. Requests for such letters should be addressed to the President, Dr. Robert T. Orr, California Academy of Sciences, Golden Gate Park, San Francisco 18, California, together with suggestions as to content and officials to whom the letter should be directed.

LINNAEAN BICENTENNIAL

The Society of Systematic Zoology is holding its 1958 annual meetings in conjunction with the AAAS at the Shoreham Hotel, Washington, D. C., from December 28–30. Symposia on nomenclature and systematics will include much of general interest to mammalogists.

CORRECTION

In Vol. 39, No. 3, p. 409, the letters *A*, *B*, *C*, *D* and *E* on Fig. 1 should be, respectively, *C*, *D*, *B*, *A* and *E*.

DEATH REPORTED

P. F. English, October 8, 1958

THIRTY-EIGHTH ANNUAL MEETING

THIRTY-EIGHTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF MAMMALOGISTS

June 15–18, 1958

The thirty-eighth annual meeting of the American Society of Mammalogists was held at the University of Arizona, Tucson, June 15–18, 1958.

The Local Committee on arrangements was: E. Lendell Cockrum, Chairman, Prentice Bloedel, Gordon Bradshaw, Robert B. Chiasson, Larry R. Commissaris, Roger Carpenter, Robert J. Drake, C. Roger Hungerford, Keith E. Justice, Kenneth I. Lange, Joe T. Marshall and Lyle K. Sowls.

PROGRAM

SUNDAY, JUNE 15

3:30–10:00 PM—Registration, Student Union

8:00 PM—Directors' Meeting, Room 205, Student Union

MONDAY, JUNE 16

8:30–12:00 AM—Registration

9:00 AM—Morning Session

Welcome: Robert Nugent, Executive Vice-President, University of Arizona.

Response: William B. Davis, President, American Society of Mammalogists.

1. Observations on hibernation in the Uinta ground squirrel. C. Lynn Hayward, Brigham Young University, Provo.
2. Biotic communities of Dugway Proving Ground, Utah. E. Dean Vest, University of Utah, Dugway Proving Ground.
3. Observations on the yellow-footed marsupial mouse, *Antechinus flavipes*, in Australia. B. Elizabeth Horner, Smith College, Northampton, Massachusetts, and J. Mary Taylor, Museum of Vertebrate Zoology, University of California, Berkeley.
4. Use of aspen and willow in three beaver colonies in northern California. Joseph G. Hall, San Francisco State College.
5. Studies on the ecology of *Microtus richardsoni* in Wyoming. Norman C. Negus, Tulane University, New Orleans.
6. Some aspects of the ecology of muskrats in strip-mine ponds in southern Illinois. Andrew A. Arata, University of Florida, Gainesville.
7. Distribution and variation of chipmunks of the *Eutamias quadrivittatus* group in New Mexico. Eugene D. Fleharty, University of New Mexico, Albuquerque. (This paper was awarded an honorarium.)
8. Ecology and distribution of the pocket gophers of Colorado. Richard S. Miller, Colorado State University, Fort Collins.

1:30 PM—Afternoon Session

9. Nutria—and the problem we face. Stanley P. Young, U.S. Fish and Wildlife Service, Washington.
10. The distribution of pocket gophers in Georgia. W. L. Jennings, University of Florida, Gainesville.
11. A device for automatic recording of spontaneous activity in rodents. Keith E. Justice, University of Arizona, Tucson.
12. Embryo resorption in the swamp rabbit. Clinton H. Conaway, University of Missouri, Columbia.
13. Sexual maturity and age determination in Maine fishers. Philip H. Wright, Montana State University, Missoula, Malcolm W. Coulter, University of Maine, Orono, and Margaret H. Wright, Missoula.

14. Growth and development of *Reithrodontomys humulis*. James N. Layne, University of Florida, Gainesville.
15. Daily activity rhythms in *Glaucomys volans*. Mrs. Patricia J. DeCoursey, University of Wisconsin, Madison. (This paper was awarded an honorarium.)
16. Report on banding bats in the Southwest. E. Lendell Cockrum, University of Arizona, Tucson.
17. A mammalian fauna from an Indian site near Redington, Arizona. W. H. Burt, University of Michigan, Ann Arbor.
18. Bats of Sonora. Roger E. Carpenter, University of Arizona, Tucson.

7:30 PM—Smoker, Louie's Lower Level, Student Union

Illustrated talk, Techniques of photographing mammals, Ernest P. Walker, Washington, D.C.
Film, "Captive Wolves in Colorado," Mrs. Herb Crisler, Lake George, Colorado
Film, "Rabies in Trinidad," Arthur M. Greenhall, Port-of-Spain, The West Indies

TUESDAY, JUNE 17

8:30 AM—Morning Session

19. The mammal collection of the Academy of Natural Sciences of Philadelphia. Karl F. Koopman, Academy of Natural Sciences, Philadelphia.
20. Spleen enlargement associated with pregnancy and parasitism in *Peromyscus leucopus*. Wayne H. Davis, University of Minnesota, St. Paul.
21. Responses of rats to bait stations on Ponape. Kyle R. Barbehenn, Upper Darby, Pennsylvania.
22. Rats in coconut trees in Micronesia. Robert L. Strecker, Miami University, Oxford, Ohio.
23. Characteristics of Ponape rat populations. William B. Jackson, Milwaukee, Wisconsin.
24. Natural selection of color phases of Ponape rats. Joe T. Marshall, University of Arizona, Tucson.

Group Photograph, Northwest Entrance to Biological Science Building

10:45 AM—Annual Business Meeting—Election of Officers

1:30 PM—Afternoon Session

25. Comparative blood chemistry of active and hibernating arctic ground squirrels, *Spermophilus undulatus*. William V. Mayer, Wayne State University, Detroit.
26. The development of temperature regulation in the young opossum. Peter R. Morrison, University of Wisconsin, Madison.
27. Electrophoretic studies of the serum proteins of small mammals. Murray L. Johnson, College of Puget Sound, Tacoma.
28. Preliminary investigations of insecticidal control of rodent ectoparasites. John B. Bushman, University of Utah, Dugway Proving Ground.
29. Growth of *Dipodomys merriami*. Robert M. Chew, University of Southern California, Los Angeles.
30. A new classification of the recent Sciuridae. Joseph C. Moore, American Museum of Natural History, New York.
31. Observations on the desert bighorn. Gale Monson, Yuma, Arizona.
32. The Onza—a little-known form of large feline carnivore from western Mexico. Robert E. Marshall, Tucson.

6:30 PM—Annual dinner, Junior Ballroom, Student Union

8:00 PM—Film, "Look Down." Biological Sciences Building

WEDNESDAY, JUNE 18

8:30 AM—Morning Session

33. Mammals of Grand Canyon National Park. Donald F. Hoffmeister, University of Illinois, Urbana.

34. Color variation in southwestern red squirrels. James S. Findley, University of New Mexico, Albuquerque.
35. Contributions of a supple spine to speed in running. Milton Hildebrand, University of California, Davis.
36. The world's largest bats. Hobart M. Van Deusen, American Museum of Natural History, New York.
37. The baculum in microtine rodents. Sydney Anderson, University of Kansas, Lawrence.
38. Variation in the morphology of the os penis between genera of the tropical fruit bats (Pteropidae). Philip H. Krutzsch, University of Pittsburgh School of Medicine.
39. Soricidae of Arizona. Kenneth I. Lange, University of Arizona, Tucson.

10:45 AM—Final Business Session

40. The bats of Panama Canal Zone. Carl Koford, University of California field station, Hopland.
41. The status of the gray wolf in Mexico. Rollin H. Baker, Michigan State University, East Lansing.
42. A relation between body temperature and activity in five species of *Peromyscus*. Brian K. McNab, University of Wisconsin, Madison.
43. Reproductive characteristics of the mountain pocket gopher in Colorado. Richard M. Hansen, Colorado State University, Fort Collins.
44. Some life history notes on *Scapanus latimanus*. Ward C. Russell, Museum of Vertebrate Zoology, Berkeley.
45. Evidence for the fundamental relationship of rodents and lagomorphs. Stuart D. Landry, University of Missouri, Columbia.
46. Fluorescence of hair in the genus *Rattus*. Gerbert Rebell, Oklahoma Medical Research Foundation, Oklahoma City, and D. D. Davis, Chicago Natural History Museum.
47. Behavior of wolves on the arctic tundra. Mrs. Herb Crisler, Lake George, Colorado.

7:00 PM—Field trip to Colossal Cave to observe bats

THURSDAY, JUNE 19

Field trip to the Southwestern Research Station of the American Museum of Natural History, located in the Chiricahua Mountains near Portal, Arizona

Field trip to the Arizona–Sonora Desert Museum

DIRECTORS' MEETING

The Board of Directors convened at 8:00 PM June 15, 1958, in Room 205 of the Student Union Building, University of Arizona. Minutes of the previous meeting were read and approved. The Secretary-Treasurer presented the following changes in the membership list: 174 nominees, 42 resignations, 10 deaths, 42 delinquent for three consecutive years. Removal of the latter from the rolls was approved. The report of the financial audit of the Society's books was presented and approved. The report of the Trustees was presented by S. S. Gregory and approved. The report of the Editorial Board was presented by R. H. Manville and approved. It was decided that the practice of providing authors with free reprints of articles printed in the Journal of Mammalogy be discontinued effective January 1, 1959. The Editor and Secretary-Treasurer were authorized to prepare and publish within a year a copy of the membership list and a copy of the Bylaws and Rules of the Society.

The following budget was adopted for 1958:

Expenses of the Journal of Mammalogy	$10,200.00
Expenses of the Office of Secretary-Treasurer	1,500.00
Editorial Expenses	150.00
Membership Committee	50.00
Index Committee	100.00
Honoraria	200.00
Zoological Record	100.00
AIBS	100.00
Audit	50.00
Contingent Fund	150.00
Capital Outlay	300.00
Total	$12,900.00

D. D. Davis was appointed to succeed himself as Trustee for the 1959–61 term. R. H. Manville was reappointed as Editor of the Journal of Mammalogy. Transfer of $3,000.00 from the income of the Endowment Fund and $900.00 from the J. A. Allen Memorial Fund to the Treasurer for publication of the Journal was authorized. $2,444.23 derived from sale of back issues and life membership payments was transferred to the Trustees for investment. No action was taken on invitations for a 1959 meeting place. The Secretary-Treasurer and Recording Secretary were instructed to prepare an amendment to the rules to be presented to the Society for adoption, providing a revised order of business consistent with the new organization of the Society.

ANNUAL BUSINESS MEETING

The first session of the annual business meeting was called to order with 96 members in attendance. The minutes of the previous meeting were read and approved. The following new order of business was presented and approved:

The order of business at the annual meeting, unless changed by a two-thirds vote of the members present, shall be as follows:

1. Reading and approval of the minutes of the previous meeting.
2. Appointment of temporary committees and tellers.
3. Report of the Secretary-Treasurer.
   a. Statistical summary
   b. Election of nominees to membership
   c. Financial report
4. Report and recommendations of the Board of Directors.
5. Consideration of amendments.
6. Election of Officers and Directors and reports of Committees.
7. New and unfinished business.
   a. Reports of representatives to other Societies
   b. Presentation of resolutions
   c. Selection of next place of meeting
   d. Other business
8. Adjournment.

One hundred seventy-four names were presented by the Secretary-Treasurer for election to membership in the Society, and elected. The deaths of 10 members, including honorary members (*), charter members (†), life members (‡), and emeritus members (§), were announced: W. A. Black†‡, Mary Allison Bennett, W. B. Cadwalader‡, Herbert Lang†‡, Eleanor J. Leland, E. A. Preble*†, William Rindsfoos†‡, Karl P. Schmidt‡, John T. Zimmer†, and William A. Rowan§.

The following summary of memberships and subscriptions was presented:

		Minus	*Plus*
Membership			
Changes since last report:			
	Nominees		107
	Resignations	42	
	Deaths	10	
	Delinquents dropped	42	
		94	107
	Net Change +13		
Status of Members as of December 31, 1957:			
	Honorary		6
	Life		101
	Honorary and Life		3
	Emeritus		3
	Annual		1,358
	Delinquent		107
	Total		1,578
Subscriptions			
Changes since last report:			
	Cancelled		39
	New		118
	Total		576
	Net Change +79		
Mailing List:			
	Total membership		1,578
	Members not receiving Journal		114
	Members receiving Journal		1,464
	Total paid subscriptions		576
	Total mailing list		2,040

The report of the actions taken by the Board of Directors was made by the Recording Secretary.

The proposal to amend the bylaws so as to raise the dues was presented by the President (for details of the amendment see Journal of Mammalogy, February, 1958, p. 174). After much discussion pro and con the motion was defeated 52–32 (two-thirds majority required to pass).

The following officers were elected for 1958–59: Robert T. Orr, President; Stephen D. Durrant and Emmet T. Hooper, Vice-Presidents; Randolph L. Peterson, Recording Secretary. Directors elected to the 1958–60 term were: Donald F. Hoffmeister, Bernardo Villa-R., W. Robert Eadie, Hobart M. Van Deusen, and Rollin H. Baker. Philip H. Wright was elected to fill the unexpired portion of Hooper's term.

The reports of the Trustees, Committee on Conservation of Land Mammals, the Editorial Committee, the Committee on Marine Mammals, the Index Committee, the Membership Committee, and the Committee on Nomenclature were presented and approved. Durrant announced the winners of the annual honoraria to be Eugene D. Fleharty and Patricia J. DeCoursey.

At the final business session, 10:45 AM, June 18, 107 members were present. The invitation of the U.S. National Museum and the Fish and Wildlife Service to hold the 1959 meeting

in Washington, D.C., was presented to the Society and accepted. Kelson reported to the Society as representative to the National Research Council, and then presented the following reports from the Resolutions Committee, which were approved.

WHEREAS, The Territory of Alaska is blessed with unusual and valuable wildlife resources which can continue to benefit the residents of the area only if managed so as to foster perpetual conservation and use; and

WHEREAS, These resources also have incalculable scientific, recreational, and esthetic values to visitors and to scientists throughout the world; and

WHEREAS, The impending change from a Territorial to a State form of government offers a unique and challenging opportunity to establish a program of wildlife management calculated to assure these benefits for all time; and

WHEREAS, Certain recent Territorial legislation pertaining to the administration of Alaska's natural resources has been of a highly controversial nature; therefore be it

Resolved, That the American Society of Mammalogists, in annual session at Tucson, Arizona, urges all parties concerned with the proposed change of government to recognize fully the need for incorporating in the State government a natural resource administrative body empowered to carry out the most advanced methods of managing such resources in a manner to ensure their maximum benefits to mankind in perpetuity. It is further recommended that, in organizing such a body, consideration be given to the advice of a qualified and impartial group of consultants selected from persons most familiar with conservation problems and wildlife management problems in Alaska.

WHEREAS, The University of Arizona has provided excellent facilities, pleasing entertainment, superb Western hospitality, and contributed the untiring diligence of various members of its staff to the service of the 38th Annual Meeting of the American Society of Mammalogists in session at Tucson, Arizona, June 15–19, 1958; therefore, be it

Resolved, That the Society tenders its heartfelt thanks and appreciation to the University of Arizona, and to the members of the Local Committee on arrangements under the chairmanship of E. Lendell Cockrum for their hospitable and untiring efforts which have greatly contributed to the success of the 38th Annual Meeting and to the enjoyment of all members, families and friends who attended.

The Society also reaffirmed its resolution of 1957 pertaining to the setting aside of a wilderness area in northeastern Alaska.

SPECIAL DIRECTORS' MEETING

A special meeting of the Directors was called by President Davis at 11:35 AM June 18. Glass was reappointed Secretary-Treasurer of the Society. The Secretary-Treasurer was authorized to set aside monies received from the sale of indexes and back issues in a separate account for publishing future indexes or as otherwise designated by the Board of Directors. Raising of the subscription price of the Journal of Mammalogy from $6.00 to $7.00 per year, effective January 1, 1959, was approved.

President Davis then declared the meeting adjourned, and President-Elect Orr immediately called a special meeting of the new Board of Directors.

A motion to reaffirm the position of the Board of Directors as reached by mail ballot with respect to the possible necessity of raising the cost of annual dues and life memberships was passed. Discussion brought out that this action was regarded as an insurance measure which would allow early action should raising of the dues become necessary to meet the financial obligations of the Society.

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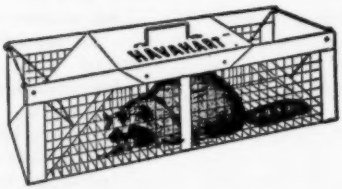

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